THE STREAM OF HISTORY
PARSONS

1.THE STREAM OF HISTORY

2. OUR FRAGMENT OF THE SUN

3. THE EVER CHANGING EARTH

4. THE MYSTERY OF LIFE

5. FROM AMOEBA TO MAN

ALASKA
CANADA
UNITED STATES
S.F
L.A
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B
N.Y
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W
MEXICO
H.
HAWAII I.
PACIFIC OCEAN
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BOLIVIA
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13.CIVILIZATION BEFORE GREECE

14. THE STORY

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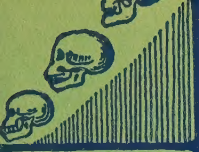

THE COMING OF MAN

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9. WHAT PRIMITIVE MAN THOUGHT

10. DAWN OF CIVILIZATION

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SIBERIA
SPAIN
FRANCE
MONGOLIA
MANCHURIA
KOREA
JAPAN
TURKEY
TURKESTAN
SINKIANG
TIBET
CHINA
LYBIA
EGYPT
IRAQ
PERSIA
AFG.
ARABIA
HEJAZ
INDIA
Sahara
FRENCH WEST AFRICA
SUDAN
ADEN
SIAM
PHILIPPINE ISLANDS
NIGERIA
FRENCH EQUAT. AFRICA
ETHIOPIA
SOMALI
CONGO
ANGOLA
DUTCH EAST INDIES
UNION OF S. AFRICA
AUSTRALIA
INDIAN OCEAN
60
80
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6. THE DARK AGES OF EUROPE

17. THE MIDDLE AGES

18. THE RISE OF THE EAST

19. THE RENAISSANCE

20. AGE OF SCIENCE AND DEMOCRACY

in Lamont

The Stream of History

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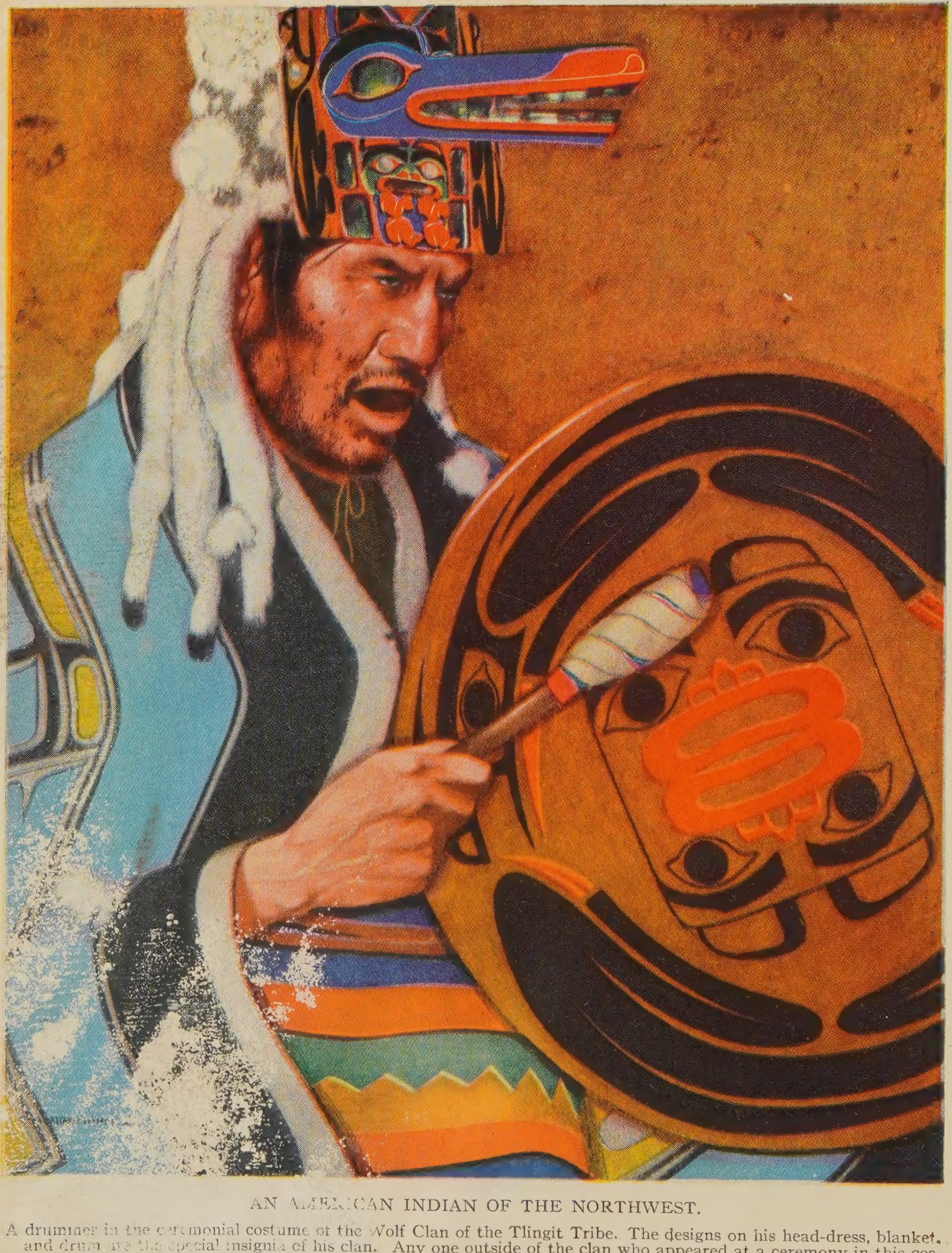

AN AMERICAN INDIAN OF THE NORTHWEST.

A drummer in the ceremonial costume of the Wolf Clan of the Tlingit Tribe. The designs on his head-dress, blanket, and drum are the special insignia of his clan. Any one outside of the clan who appeared at a ceremony in this costume would probably be murdered.

From a painting by W. Langdon Kihn.

The Stream of History

By

Geoffrey Parsons

Volume I

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1930

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PREFACE

This short sketch of the past has one principal aim, to present the centuries not as the mountains of sunlit fact which history has tended to portray, but rather as a stream of mingled fact and theory, now clear, now muddied by passion and prejudice, eddying about this hero or that, and reaching each generation through the shifting channels of individual minds. There has been a slow gain in certainty as to facts. But the last century has exaggerated the gains in interpretative and useful wisdom. The extraordinary growth of science within its chosen territory has tended to obscure the vast unknown which surrounds the limited fields of fact and logic. The application of scientific method to certain of the data of history has misled its followers into assuming that not only the facts of the past but, in addition, man's conclusions therefrom, were approaching finality. The truth is rather that complexity increases as new approaches to the past are discovered.

The writer has aimed to tell the whole story of man and his earth and to tell it so swiftly and simply that its essential parts will stand forth in their due relationships unobscured by detail. Condensation and elimination have necessarily been extreme; no major fact, whether of science or art, of commerce, war, industry, or conscience, has been intentionally slighted.

The effort has been to take the reader behind the scenes of historical writing and present the possible alternatives of interpretation. Yet a neutral version has been neither hoped for nor sought. The very words of history prevent a scientific detachment. They come to our minds trailing clouds of ancient passion and prejudice whether we will or not. Impersonal history is an impossibility. Many of the works best worth reading are intensely partisan and unfair. History is a science only in respect to a small substratum of demonstrable truth. In all the important judgments of men and institutions and all the theories built thereon, history is an art, the creature of man's imagination and that practical wisdom which, using what ground reason can clear, leaps boldly into action across the remaining ditch of doubt.

The writer has consistently sought, therefore, in stating his personal opinion, to present as well the major disagreements of the experts and to stress the tentative character of every judgment. The volume thus presents no novel or revolutionary interpretation of the past. It is based on a study of the authoritative works, ancient and modern. An especial debt relating to method runs to certain pioneers in the art of vivid simplification, to Professor James Henry Breasted, Miss Edith Sichel, Professor R. R. Marett, and Professor John Linton Myres, who found distinguished scholarship no bar to making the past the common property of the present. The result, if the endeavor has succeeded, is to furnish not so much a summary of the past as an analysis of its problems and therewith a point of view for its continued study.

It is impossible to thank all those who have aided in the writing of the book, by their suggestions or criticisms, but especial acknowledgment is due to these friends, Mr. H. A. Cushing, Miss Marcia Dalphin, Mr. Clarence Day, Doctor E. E. Free, Mrs. Isabel Leavenworth, Professor Ralph V. D. Magoffin, and Mr. William L. McPherson, who have read the manuscript, in whole or in part, and, without being in any wise responsible for its failings, have contributed materially to such merit as it possesses.

G. P.

Rye, New York,
April 10, 1928.

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The Stream of History

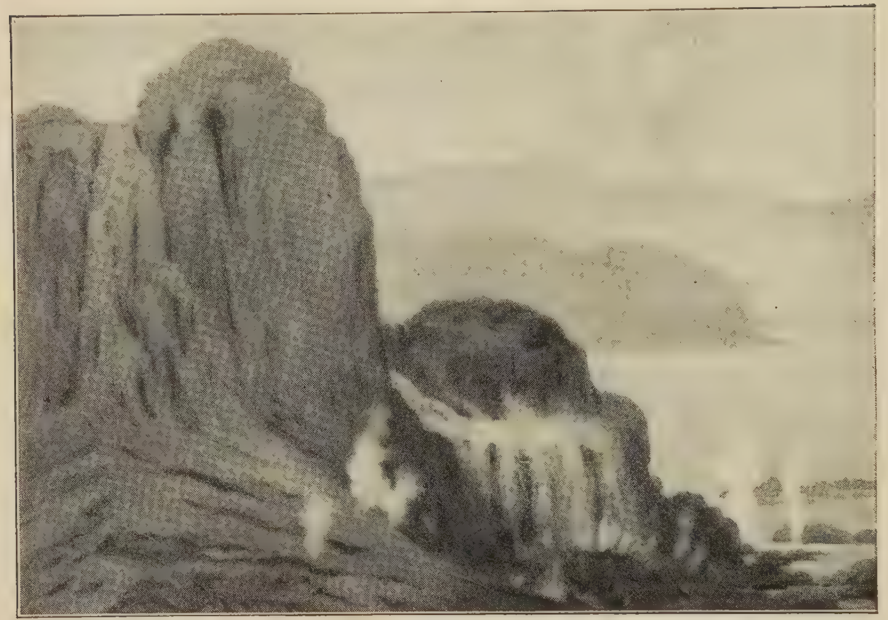
CHAPTER I

THE STREAM OF THE PAST

THERE was once neither printed page nor man nor earth. Of the solar system, there was only a great sun soaring through space. In an hour of flame and rending it sent forth blazing fragments which cooled into dark and spinning balls circling about the sun and shining in its light. Upon one of the smaller of these has developed all that we live among and are, mountain and ocean, green things, fish, the great animals of the land, and, finally, mankind.

The earth is still turning from the force of that first thrust. But it is destined to turn more and more slowly. It is in a sense dying; and some day long hence, as far in the future as its beginning is far in the past, it may cease to turn upon its axis, it may halt in its orbit about the sun. It may come to rest and hang cold and lifeless in space, perhaps to fall back into the sun, ending in flame, as it began.

This is the story of that fragment of the sun and of the adventure that has happened thus far upon its flight. Millions of years have come and gone for each change upon it. It is hard before such a confusion of events, such spaces of time, to picture all this as one stream of flowing fact. But scientists of many generations, working from every angle



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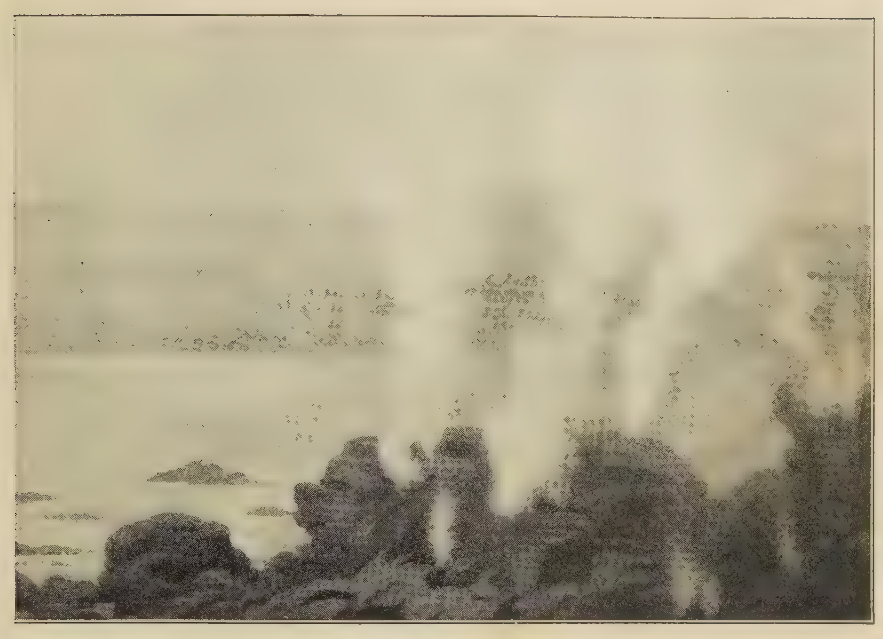
THE COOLING
From a painting by

of approach, the astronomer, the chemist, the biologist, the many others, have brought an amazing order into this chaos. They have taken these millions of years and these masses of events and commenced to build of them a single body of truth which is called science. Each gain in knowledge has meant lifetimes of great minds, years of devoted labor. The task is but fairly begun. The unknown still far exceeds the known. When human actions are reached, facts elude and theories shift and falter. Yet already men of to-day, looking through these many eyes, seeing with this wisdom of the centuries, stand as upon a hilltop and are able, as no men were ever able before, to view this spectacle of the earth and its career as a single swift and moving tale.



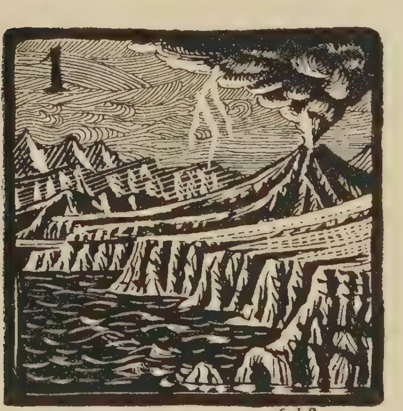
EARTH.
Charles R. Knight.

I. IF EONS WERE DAYS

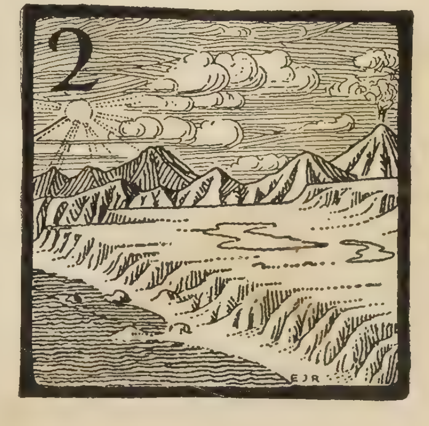
If there were a moving picture of this story, its film could be turned more and more quickly. In this fashion ordinary movements, a plant growing, a man walking, a horse trotting, can be shown as if passing at fabulous speed. Conceive a record of the earth presented in this manner. Picture its progress so hastened that a million years is a few minutes and its hundred or more millions of years pass in a few days. The result will distort details and omit much. But the general survey will help preserve perspective in the pages to follow. Above all, it will strengthen a sense of the singleness of the stream which is the past.

The film begins at the point in time when the earth has become cool and solid and the planets march about the sun as to-day. It is impracticable to begin earlier, for the formative stage of the earth is too vaguely outlined to permit even a guess as to its duration.

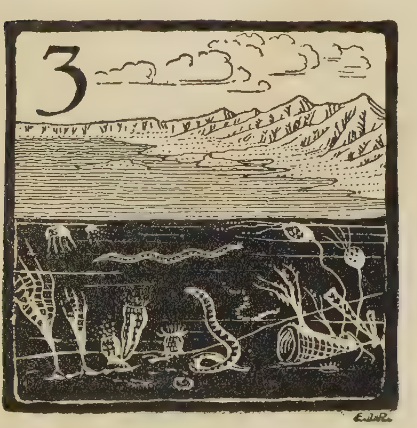
The proportions of the schedule that follows are based on the roughest estimates. One must think of it as a rude plan with no pretense to mathematical accuracy. One can feel some confidence that if the career of the earth were divided into five parts, the picture of each part would run somewhat as shown. But the duration in years of the whole period, and of each part, can only be estimated. One is dealing with more millions of years than the mind of man can conceive. The earth matured at least five hundred million years ago, probably more than a billion years ago. Each of the five days that follow stands for not less than one hundred million years. With each ticking of the watch, there pass centuries. Age-long, invisible changes take minutes. Continents upheave like leviathans, and sink again beneath the waves. The whole earth stirs like a living thing.



First Day. In the beginning there is an earth bare and terrible. Flame pours from a thousand volcanoes. Streams of lava flow far and wide. Not a tree or blade of grass shows on the land. Only the tides stir in the empty seas. Day long great mountains are washed into the sea by the savage storms, and new mountains upheave. It is an earth fresh from chaos, and so it remains throughout the day and night.

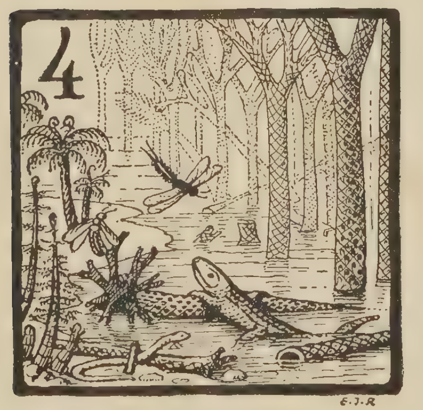


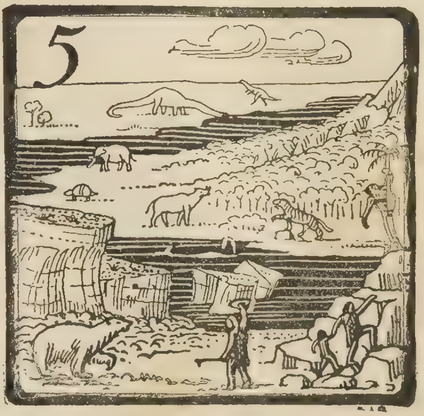
Second Day. Slowly in the morning the smoke and flame begin to abate. The clouds lift. The lands that stand forth to view are still bleak rock and barren sand. But somewhere life is beginning, perhaps in the inland pools, perhaps along the edge of the warm sea, a gray jelly, floating where the tides will, an inconspicuous scum. No onlooker would notice it alongside the great mountain ranges that are folded aloft by the shrinking shell of the earth. Yet it has the power of growth and development, and it is destined to be mightier than all the hills.



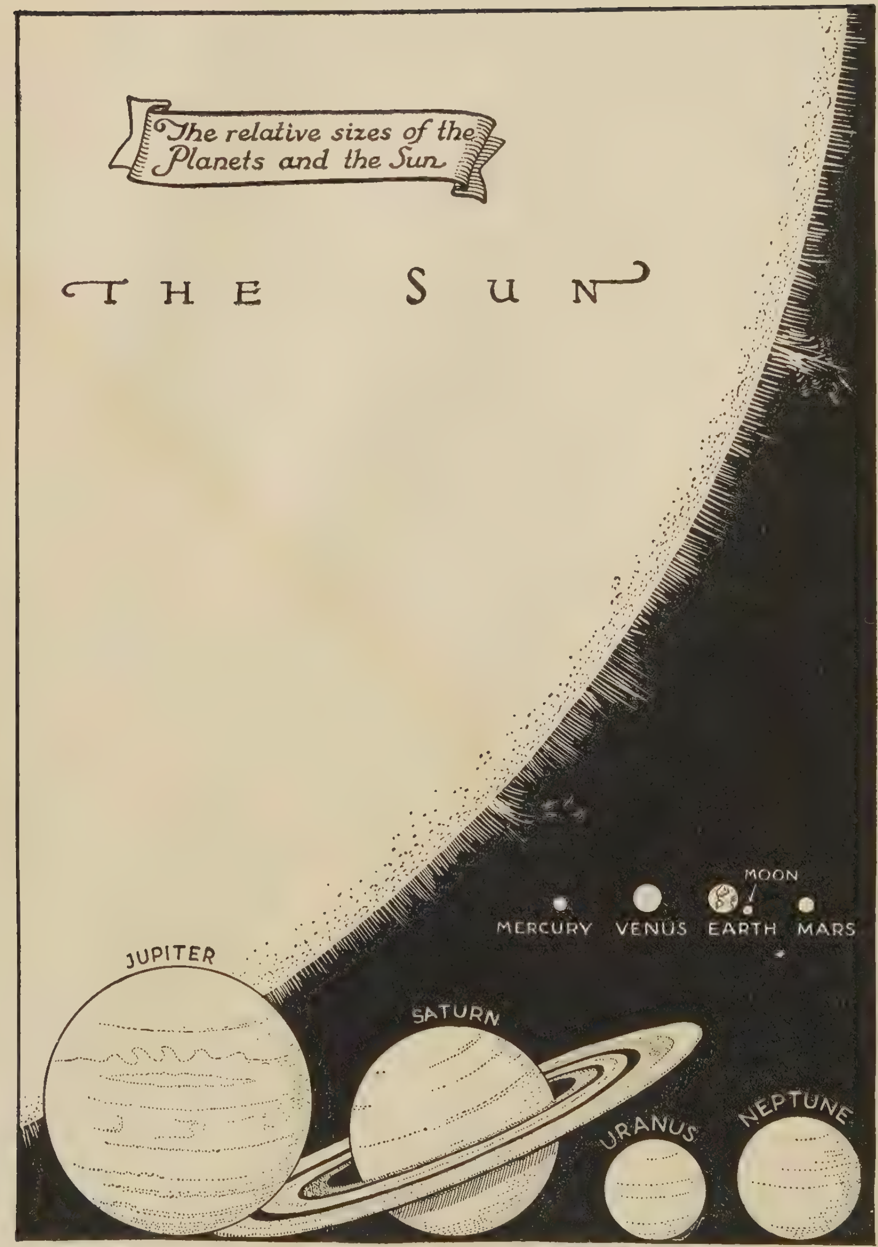
Third Day. Still the dry land rises desolate and brown. Only in the sea are change and progress. There the first tiny animals drift about and seaweeds sway in the current. Toward evening the sea becomes alive with countless forms of life, with sponges and sea-anemones and jelly-fish, all the round, backboneless creatures of the deep. Finally, in the last hours, comes the great triumph of the day, a worm, boasting the first brain the earth has seen. More than half the life of the earth is past, and the only moving things on the continents are the great hills that cycle upon cycle are crumpled silently aloft and as silently flow into the sea.

Fourth Day. The lands are quieter as this day dawns, and hour by hour the first green plants begin to march from the sea to the dry land. Shallow seas spread over the low places of the continents and retreat again as the lands gently heave and fall. On the marsh-lands sprout great forests of fern-trees as tall as oaks, which presently are lying beneath the deltas of rivers and turning to coal. Meanwhile under water the first fish swim and oysters and clams and periwinkles grow their shells. Clumsy, shuffling creatures crawl hesitatingly out upon the shore for a while, and the long line of land-animals is in sight. Insects grow wings and buzz amid the great ferns, giant dragon-flies two feet across the wings. Great armored crocodiles rule the marsh-lands. At midnight the first Appalachian Mountains upheave, as high as the Alps to-day.





Fifth Day. The morning of this crowded day sees the rise and decline of the giant reptiles, the great eighty-foot dinosaurs and the flying dragons twenty-five feet across the wings. True feathered birds take wing, the first flowers bloom, and the first mammals, the size of kittens, suckle their young. One of the mightiest of all mountain-makings comes at noon, folding ranges aloft from Alaska to Cape Horn. Not till the middle of the afternoon do the modern mammals begin to appear. Then one after another of the great line steps forth from the forest—elephant, tiger, bear, leopard, bison, and deer. The whale flops back into the sea. The first monkey takes to the trees. In the middle of the evening comes the last of the great mountain uplifts. The Alps and Himalayas are folded aloft across Europe and Asia; the Rocky Mountains are thrust up again. In the very last hour begins the Great Ice Age. Vast ice-floes march down upon northern America and northwestern Europe. In the last half-hour appears man, the hunter and savage, fighting for his life on the edge of the retreating ice. The whole story of historic man, from Ancient Egypt to the World War, passes in the last twenty-three seconds of this Fifth Day.


The relative sizes of the Planets and the Sun
THE SUN
MOON
MERCURY
VENUS
EARTH
MARS
JUPITER
SATURN
URANUS
NEPTUNE

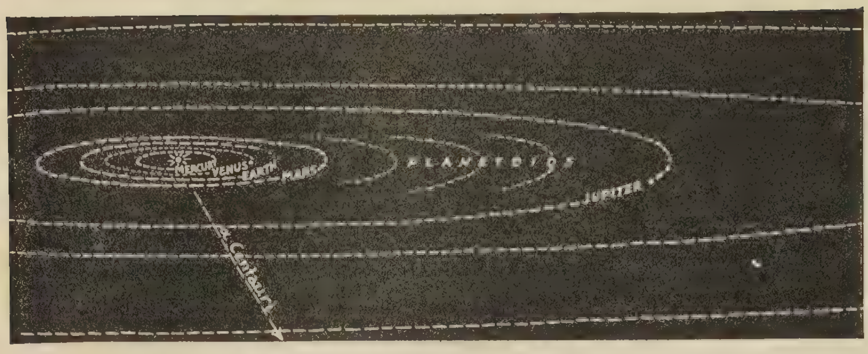
CHAPTER II

OUR FRAGMENT OF THE SUN

It was an hour of flame and ruin that brought the earth into being. A giant sun was torn and riven, and the void round about was filled with crashing worlds. This much is reasonably sure. The manner of the catastrophe is another matter. Man is not certain of it, and probably never can be certain of it. There were no witnesses. The records were consumed as they were born or else lie hid in the heart of the earth. The astronomer alone can attempt to sketch a picture of this far event.

He has two main sources. One is a study of the peculiar arrangement of the solar system. The other is the observation of the heavens, where similar births may be taking place. The former has led to a general acceptance of the view that the earth and the other planets were in some fashion born of the sun; the latter has fixed attention upon those faint and cloudy bodies of the sky, the nebulæ.

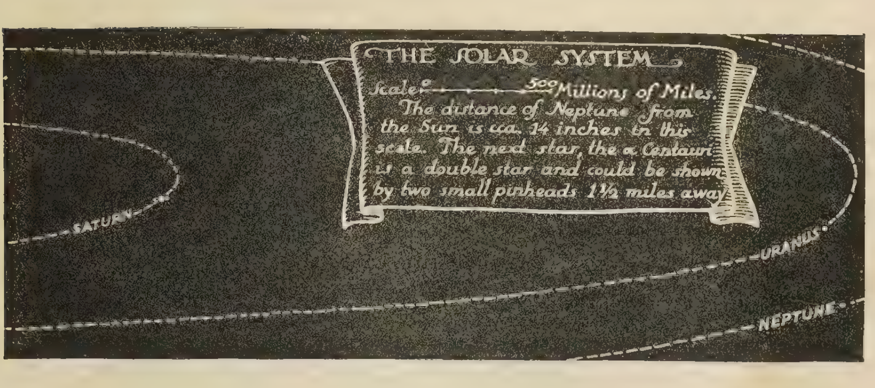
The sun and its planets, separated by as many millions of miles of cold and empty space as they are, form a close family group compared to the fixed stars and the distances which separate them from one another. A dot on one corner of a blackboard for the sun and another dot two inches away for the earth would place Neptune, the farthest planet, five feet



away. The whole solar system can be represented on these few feet of blackboard, Mercury and Venus lying in the two inches between the earth and the sun, Mars, Jupiter, Saturn, and Uranus between the earth and Neptune. The nearest fixed star is *a* Centauri of Centaur (in the southern hemisphere of the sky). Continuing the scale of the blackboard, it lies out the window and across the fields almost a mile away. The other fixed stars would be even farther.

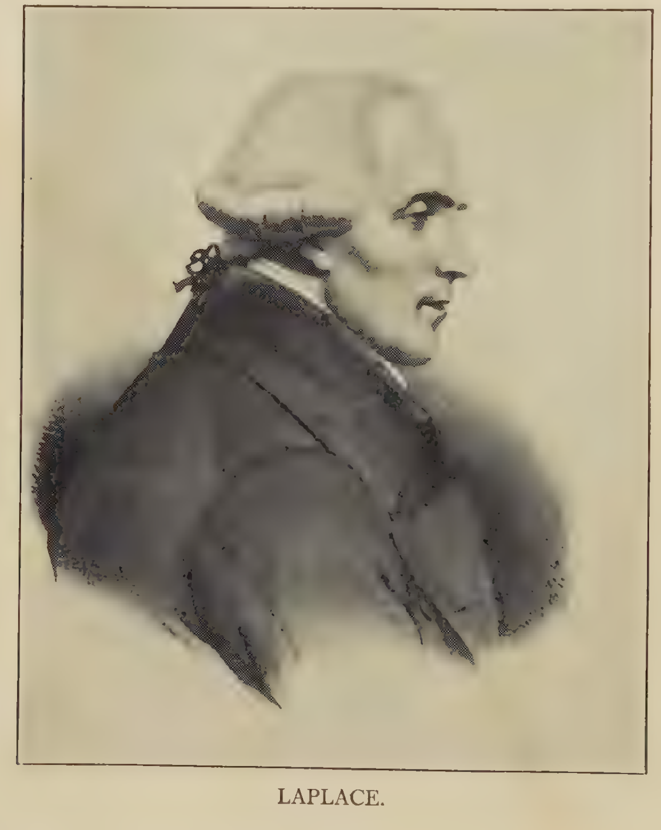
In one respect the universe is thus very much what it appears to be at night, relatively tiny points of light separated by vast emptiness. It is of bleak barren space that the world chiefly consists, huge as are many of the fixed stars, far greater than the sun. In another respect, however, the appearance of the sky is most deceptive. The planets, the brightest of which, Venus and Jupiter, might pass for large stars, are really much smaller bodies relatively close at hand and forming a true family group.

The fashion in which this group is arranged is highly significant. At the centre is the sun, so much larger than the


THE SOLAR SYSTEM
Scale 0 500 Millions of Miles.
The distance of Neptune from the Sun is cca. 14 inches in this scale. The next star, the α Centauri is a double star and could be shown by two small pinheads 1½ miles away
SATURN
URANUS
NEPTUNE

planets that they circle around it just as one might swing a stone around one's head at the end of a string. Tying the planets to the sun is the attraction of gravity, which holds them in their courses just as surely as string could hold a stone. Against this force of gravity works the tendency of each planet to fly off into space by reason of the fact that it is whirling around the sun—just as the stone at the end of the string would fly off into space if it were not tied fast. These two forces are exactly balanced in the case of each planet; that is why the solar system revolves century in and century out with such beautiful precision.

One can obtain a feeling for this hugeness of the sun and the smallness of the circling planets by reducing their scale and laying them off on the surface of the earth. If the sun were reduced to the size of a six-foot push-ball, such as teams of players push about a field, the earth would be a large marble set down 200 yards away. The planets between the earth and the sun are smaller than the earth. Mercury, the smallest and the nearest the sun, would be a small pea, Venus a marble slightly smaller than the earth. Beyond the earth would come first Mars, a large pea, then the small fry of the system in the belt sown with planetoids,* and finally the



LAPLACE.

four great planets. Of these the first would be the largest, Jupiter, almost the size of a football three-fifths of a mile from the sun; and the last Neptune, the size of a baseball over thirty miles away from the sun. A baseball that distance from a push-ball seems isolated enough; but the nearest fixed star is immensely more remote. On this particular scale

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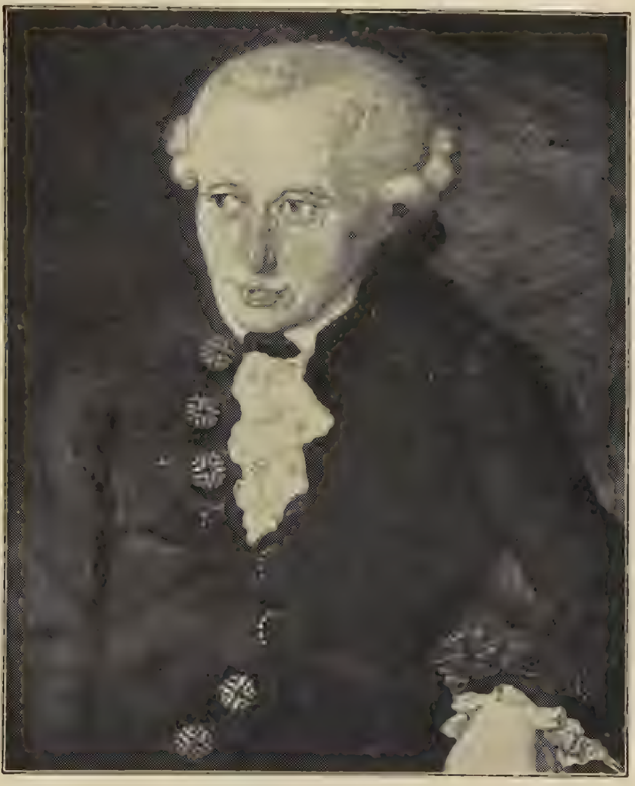
*The old word for these small planets was asteroid. It is being discarded because it suggests that these bodies are stars (asteroid is from the Greek, meaning a star) shining from their own light, whereas they are really cool, dark bodies like all the planets.



KANT.

the nearest star, *α* Centauri, would be farther off than China.

These tiny representatives of the planets have been pictured on a level with each other and with the sun, and that also represents the truth. It is the second striking fact about the planets. They and the sun all move in the same plane, or nearly so. The only exceptions are some of the planetoids.

The third is that the orbits of the planets have nearly the same shape—that is to say, they are all slightly elliptical, or, put the other way, nearly circular.

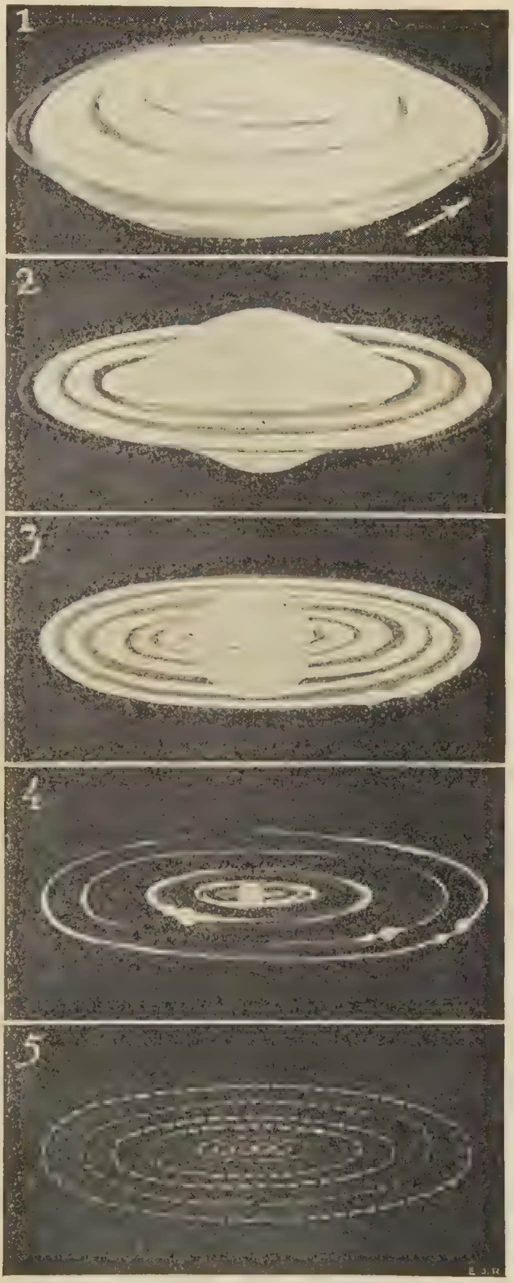
The fourth is that they all revolve on their axes in the same direction.

The fifth is that the moons, with a few exceptions, revolve about their planets in the same direction that the planets revolve.

There are other facts of a more technical nature which point in the same direction. The system is, in general, exactly what one would expect to find if the whole once formed a great body and pieces had been broken off to form the planets. The coincidences are too many to be withstood. Such a peculiar arrangement might have been otherwise formed by a strange succession of events; some one has calculated that the chances against any other origin are many billions to one. So the astronomers come out at something very close to certainty on this point.

If the system came from one body, how was it formed? Science does not pretend to give a final answer. One needs to learn the slow ways of science and to share its attitude of reserve toward its trial theories. Here is a point of view that will help throughout, for all knowledge is growing and changing and there is as much danger in knowing overconfidently as in much ignorance.

A trial theory put forward in a science is called an hy-



1. A round nebula of hot gases as large as the entire solar system.

2. Cooling, its interior shrank away from its bulging equator.

3. It separated into a series of gaseous rings.

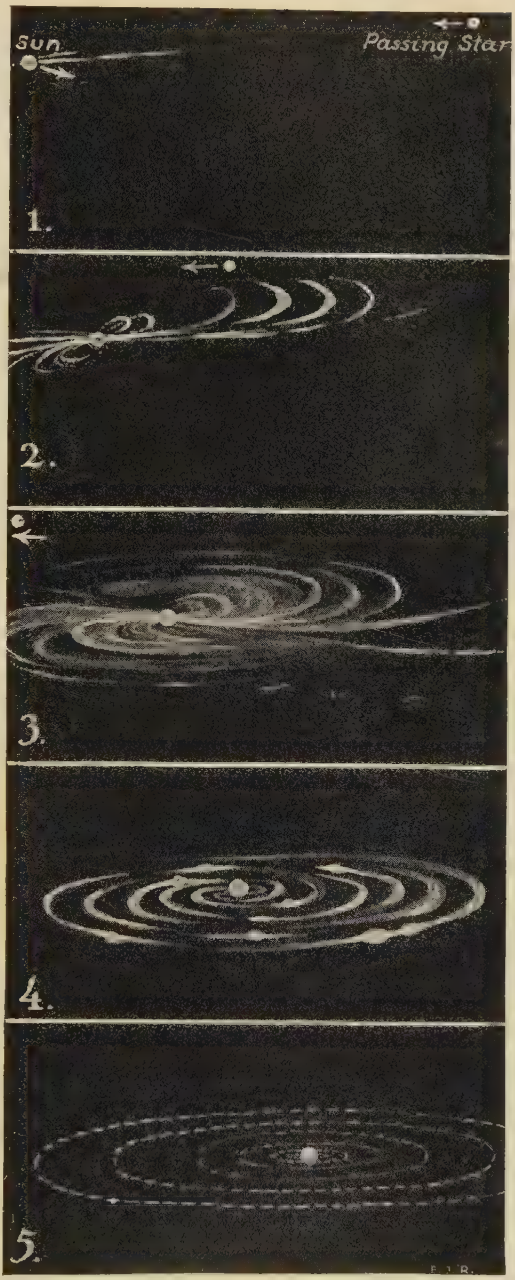
4. Each ring thereafter assembled into a sphere still swinging about the core, now contracted into the sun.

5. And formed the solar system of to-day.

NEBULAR HYPOTHESIS.

pothesis. It is a guess, but a guess based on a long gathering of facts patiently studied. The germ of such a guess may come in a flash, suggested by some simple happening, like the falling apple that suggested the law of gravity to Newton. In any event it is a work of the imagination quite as much as is any poem or statue. Once published, it comes under a fire of criticism from the entire world of science. It is tried and tested in every conceivable fashion. It stands or falls according as it successfully agrees with the facts brought forward to test it. All scientific progress has been over the remains of discarded hypotheses. Not one in a thousand stands in its original form. Such as still stand are in every degree of test and approval, from early speculation to acceptance as useful scientific laws; and even these latter are subject to revision and growth.

The nebular hypothesis, which suggests that the solar system originated from a nebula, was first put forward in definite form by the French astronomer Laplace in 1796; but, as with almost all scientific discoveries, there were many forerunners, notably the German philosopher Kant in 1754–1755. This theory starts with a great round nebula of very hot gas, far larger than the present sun, as large, indeed, as the entire solar system, so that the outermost planet, Neptune, would be included in it. This huge sphere revolved in the same direction that the planets now revolve around the sun. Thus revolving, it cooled and shrunk. In shrinking, the equatorial belt of the sphere would feel the greatest effect of



1. Our sun, swinging alone through space, is approached by another big sun.

2. Subject to the gravitational pull of the passing star, the sun shoots out on opposite sides two flaming tongues.

3. A portion of the explosion would fall back into the sun; another portion might be propelled into space. The rest of the two arms would remain in equilibrium circling around the sun.

4. The mass would soon cool and the larger knots of material begin to collect the smaller bodies around by a succession of collisions.

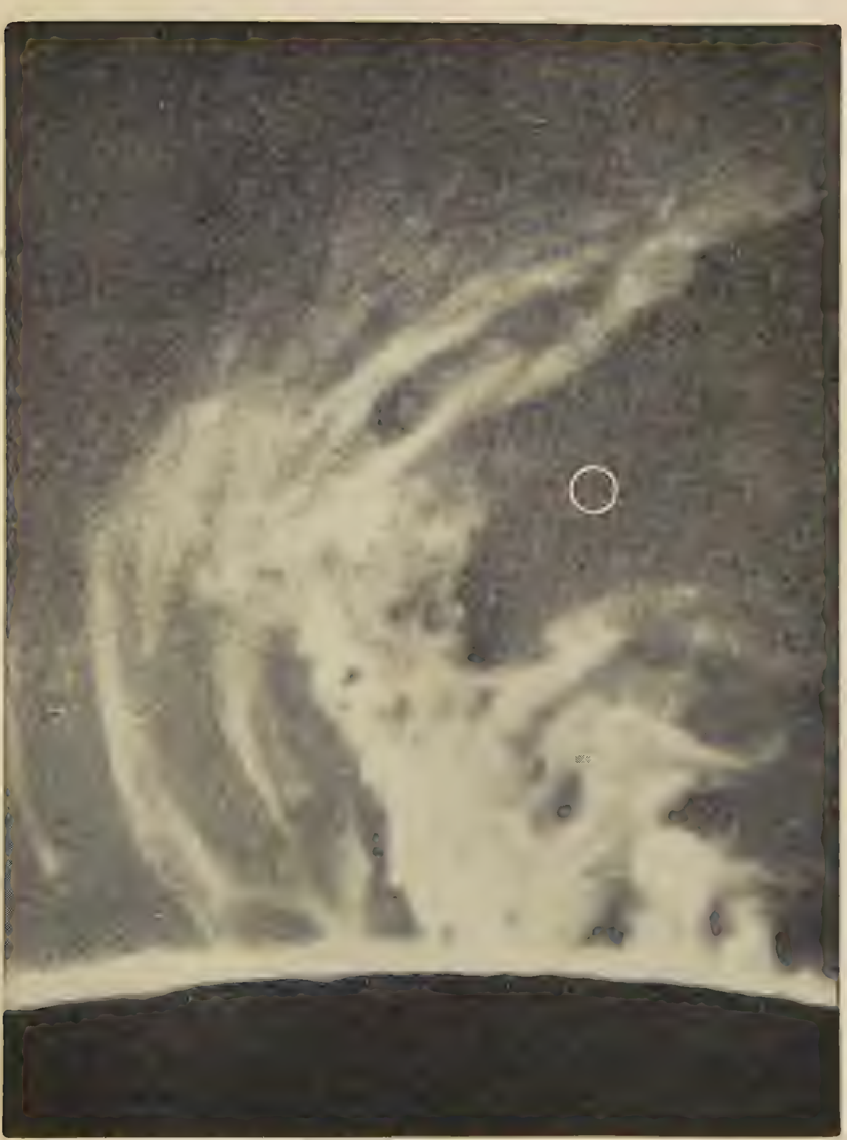
5. Each knot would ultimately clean up its orbit excepting only the moons, rival knots of matter that escaped collision but were captured as satellites.

PLANETESIMAL HYPOTHESIS.

centrifugal motion, and the hypothesis holds that this belt of gas would in time be left behind as a separate ring. It is commonly said that this ring would be "thrown off" by the swiftly whirling sphere, but it is more accurate to say that the interior of the sphere would shrink away from its bulging equator. This process would be repeated until a series of gaseous rings surrounded the core, a ring for each planet; each ring thereafter assembled into one sphere still swinging about the core, now contracted into the sun. The planets thus formed were conceived as still in a hot gaseous state, and they in turn contracting gave off rings in exactly similar fashion which became their moons. The rings of Saturn would be matter thus given off that for some reason failed to assemble into moons. They are the type of ring that Laplace had in mind, and probably suggested the theory.

This is a very beautiful and simple explanation. It was widely favored for a long while, but for the past fifty years it has been under increasing criticism, and at the present time is gravely doubted. The objections to it are highly technical, coming largely from physicists and mathematicians, who have argued, in effect, that a gaseous sphere could not give off rings in this fashion. A number of modifications of the original Laplace formula have been put forward in an effort to meet these objections, but none has solved the difficulties involved in this form of origin.

At the present time the eyes of scientists are turned toward a new and entirely different theory of origin that has



From Dr. George Ellery Hale's "The New Heavens."

GASEOUS PROMINENCE OF THE SUN'S LIMB 140,000 MILES HIGH.

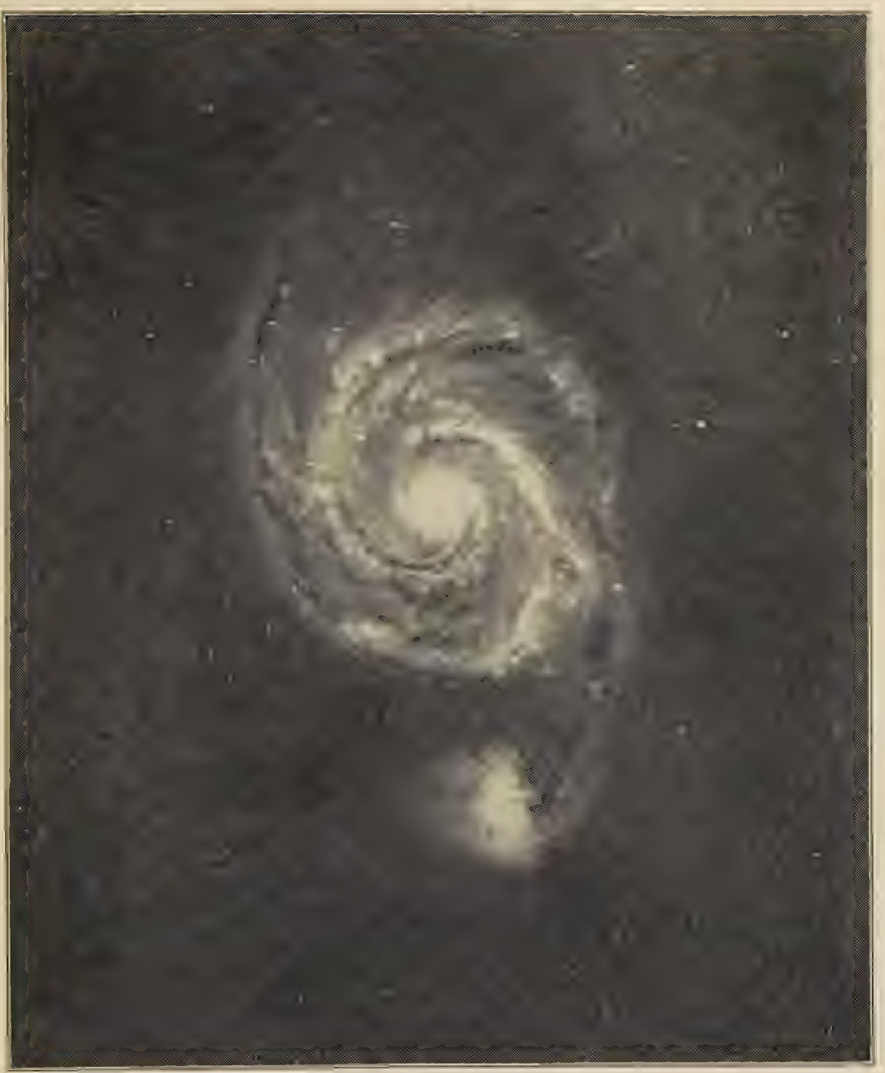
The size of the earth is indicated by the white circle.

been developed in the past generation. It is the work of two Americans, Professors Chamberlin and Moulton, of the University of Chicago. It is known as the planetesimal hypothesis, to distinguish it from the nebular hypothesis of the Laplace theory. A planetesimal is simply a very small planet, and in general the theory holds that the planets were built up not from rings of gas but from small solid bodies by collision one with another. The detailed theory is picturesque and dramatic. It should be understood that this new hypothesis is now undergoing test; but it can be said that it presents far fewer difficulties than does the Laplace theory and has already gained wide acceptance.

The theory starts not with a huge sphere of thin gas but with a sun, like our present sun, somewhat larger. One must picture this sun, swinging alone through space, approached by another great sun. The theory calls for a case where these two enormous bodies come close enough to exert a powerful tug of gravity upon each other without being completely swept from their established orbits. Had they been so swept, they would have crashed together in one consuming cataclysm. For an additional point, the other sun could not have been too large, for its gravitational pull would then have disrupted our sun completely and scattered its fragments to the four winds. It can be seen upon what rare and delicate relationships existing between two great suns, rushing past one another, millions of miles apart in the cold night of space, this theory rests the birth of the earth.

What happened to the sun from this approach was exactly the sort of pull that the moon exerts upon the oceans of the earth. That pull produces the tides, a wave lifted up from the level of the sea by the gravitional pull of the moon. Now the sun, intensely hot and gaseous, is far more elastic than the sea. Subjected to a similar pull, the theory holds that it would shoot out on opposite sides two great flaming tongues reaching millions of miles into space. Why two such projections on opposite sides? For the same reason that the moon gives two tides a day, although it passes across the sky but once a day. The moon draws a tide in its wake on the side of the earth toward it, and leaves a corresponding one on the opposite side. This is in accord with the laws of physics, though somewhat difficult to understand at first thought. The general idea is that the moon exerts its greatest pull on the water nearest it and its least pull on the water farthest from it. Thus two waves are set in motion, one the result of the direct pull of the moon, the other a bulge left on the far side where that pull is weakest. (The actual tides are the result of many complicated factors, but this is the initial cause.)

The sun, as a matter of fact, constantly shoots out tongues of flame to many thousands of miles. Astronomers have calculated that were it not for the resistance offered by the immense atmosphere of the sun, these flames would reach past us, licking the farthest planets. Not very huge protuberances are needed to account for the solar system. All the planets



From Dr. George Ellery Hale's "Beyond the Milky Way."

A TYPICAL SPIRAL NEBULA PHOTOGRAPHED AT THE MOUNT WILSON OBSERVATORY.

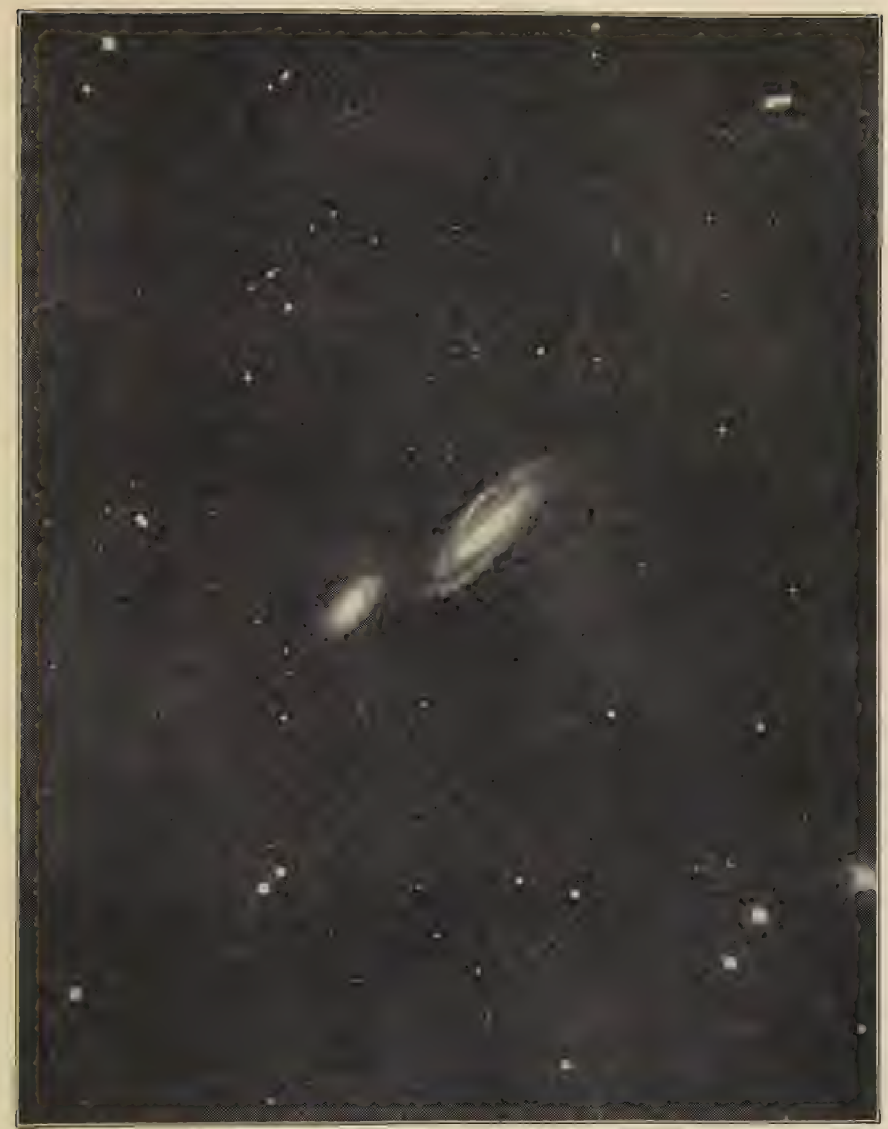
and their satellites amount to only $\frac{1}{700}$ of the entire mass of the solar system. A portion of these explosions would fall back into the sun like the water of a vast geyser, pulled in by gravity, after the other great sun passed on; another portion might be propelled so far that it would escape from the gravitational pull of the sun altogether and go wandering off into space, lost planets, lost for all time. The rest of the two arms would remain in equilibrium circling about the sun exactly as circle now the planets. The entire amount of matter exploded from the sun need have been only one or two per cent of its mass.

The two arms would not stand out straight, however. Their ends would fall behind the revolving sun at the centre exactly as the spurts of fire from a pinwheel bend backward. There would result a thin flat spiral, with two curving arms, projecting from the sun as a centre. It was at first thought that this part of the theory was supported by the observed facts of the sky. By far the largest number of the nebulæ are believed to be spirals of this general description. There are hundreds of such nebulæ in the sky, of varying size, brilliancy, and distribution of parts, all possessing the form of a two-arm spiral. (Not a single one-arm spiral of the watch-spring type has been noted.) These nebulæ, however, are millions of times vaster than the nebula from which our system might have grown and their origin was probably due to other causes. They cannot be considered as akin to our solar system or as in any sense portraying its birth.

Such an explosion as has been described would not be a simple affair. Rather would it be a series of explosions, and each explosion would expel varying material, some light, some heavy. It is easy to see how great balls of matter would be erupted together. All alike would cool swiftly from a gaseous to a liquid, and perhaps even a solid, state according to this hypothesis. If there were a photograph of the spiral nebula now conceived as the ancestor of this system, it would show four small knots not far from the centre which would be the beginnings of the four smaller planets, of which the largest would be the earth; beyond this would be a belt with no centre of commanding size, this being the zone of the planetoids; and outside this would come four larger knots representing the four larger planets.

The courses of these knots and of the planetesimals would be anything but the orderly orbits, almost circles, of the present planets. They would crowd about the sun in a jumble of ellipses, and collisions would be frequent. The large knots would receive and hold the infalling masses; and thus from small beginnings by a succession of collisions, great and small, would grow the planets. Each would ultimately clean up its orbit, excepting only the moons, rival knots of matter that escaped collision but were captured as satellites.

By this hypothesis the moon was conceivably never part of the earth but was from the beginning a sister planet. That the earth would become the master and develop the extraordinary adventures that it has, whereas the moon never would



From Dr. George Ellery Hale's "Beyond the Milky Way."

THE LARGER OF THESE NEBULÆ SHOWS CLEARLY THE TWO-ARM SPIRAL.

grow large enough to hold an atmosphere that would permit of life, may have been written in that first fiery hour. If the planetesimal theory is true, an incalculable complexity of chances governed these twin planets, crashing through space. The infall of a few tiny planetesimals may have determined the fate of the earth and of man.

It is impossible to suggest the mathematical computations, of physics, of celestial mechanics, upon which this theory largely rests. Nor is it practicable to discuss the objections that have already been raised against it. The two alternative theories and their modifications are before the world of science. It is for science to choose between them, or modify them further, or reject them all, or remain in an attitude of doubt. In the meantime we can regard them as trial balloons of thought, among the greatest and most beautiful ventures that the human mind has sent aloft. For present truth the most that can be accepted from them with confidence is that, in some fashion, the earth and all the planets are children of the sun.

CHAPTER III

THE EVER-CHANGING EARTH

I. A GAP IN THE RECORD

If human knowledge were an orderly and mature growth, this next and nearer age of the earth would be freer from doubt than the preceding. It is, to the contrary, wrapped in greater confusion. It is one of the many gaps in the story, gaps which, for one reason or another, continue down to modern times. For man has but scratched the surface of knowledge; and even where the facts lie open before him, in modern history, for example, they have been confused by prejudice and hates which have delayed and still prevent an impartial account. The story of the Reformation is almost as unsatisfactory as these pages upon the earth before it was an earth.

The doubts as to the manner in which the earth was born prevent a clear view of its period of youth, the millions of years before the present surface of the earth was formed and a record deposited in its crust of rocks which can be read to-day with some certainty. The possibilities become more complex, the picture, for a time, more clouded. It is only a thin crust of the earth that geology can reach. What lies below in the vast heart of the earth is as hidden as is the interior of the sun or of Mars.

Furthermore, as might be expected, the oldest portions of this crust are the most torn, mingled, and confused. To interpret them is like trying to read a mass of pied type. Some day geology may be able to choose between the earlier theories of origin by deciding which fits best with its later facts. At present it cannot do so.

If the Laplace hypothesis could be accepted, the early years of the earth might be easily surmised. One can read a suggested description of them in many books. It is the older view. The earth slowly cooled from a ball of flaming gas to one of molten rocks and metals, and finally formed a solid crust outside a molten interior. It was then slightly larger than to-day and still intensely hot. Clouds hemmed it in on all sides in a perpetual night; water that condensed from the steam in the air and fell to earth hissed and rose instantly again; everywhere volcanoes belched forth their molten streams. There was neither ocean nor river nor soil nor sunlight. It was only after long ages that it cooled sufficiently to let the water of the atmosphere form oceans and rivers, and life became possible.

The planetesimal hypothesis permits a quite different picture, since it conceives that the offshoots of the sun cooled rapidly into solid masses. Professor Chamberlin applies his theory so as to keep the earth in a solid state throughout its growth. He does this by assuming that the infall of planetesimals was a slow rain of small bodies, a sort of star-dust, rather than rapid crashing of huge spheres. This infall would be spectacular—as if the earth were continually passing through swarms of huge meteors—but the increase in the surface temperature of the earth from the impact would not be great. Such heat as the earth developed would come from the increasing pressure which its gathering size by the laws of gravity would exert upon the core. From this central heat, creeping to the surface, came a period of volcanic action while yet the earth was a third its present size. Gases thus belched forth gave the earth an atmosphere and surface water when it was but little more than half grown. Professor Chamberlin conceives that the oceans may have formed thus early in much their present shape (through the building up of continents by the infall of planetesimals), and even that life may have begun on this half-size earth already in appearance not far from its present form.

But this extreme view is not the only interpretation of the planetesimal hypothesis. If the planetesimals were of great size and plunged in upon the earth rapidly, they must have kept the earth extremely hot, and the earth may well have been molten when it had cleaned up the zone of its orbit and was full grown.

The range of possibilities is great, and one had best not attempt to carry any definite picture in mind. One needs only to remember the existence of this important gap and proceed to take up the record where it becomes comparatively definite.

That is the point at which upon the earth full grown there existed the solid rock and the salt seas.

2. CLEWS IN THE ROCKS

The story of the surface of the earth is an endless cycle of building up and tearing down. For millions of years the earth has pushed up hills and mountains, only to see them levelled—this again and again and again. Nothing could seem more permanent than the great ranges, "the everlasting hills." Nothing is more certain than that they are doomed. Generations of mountains like them, standing where they stand, have come and gone. Millions of years are needed for

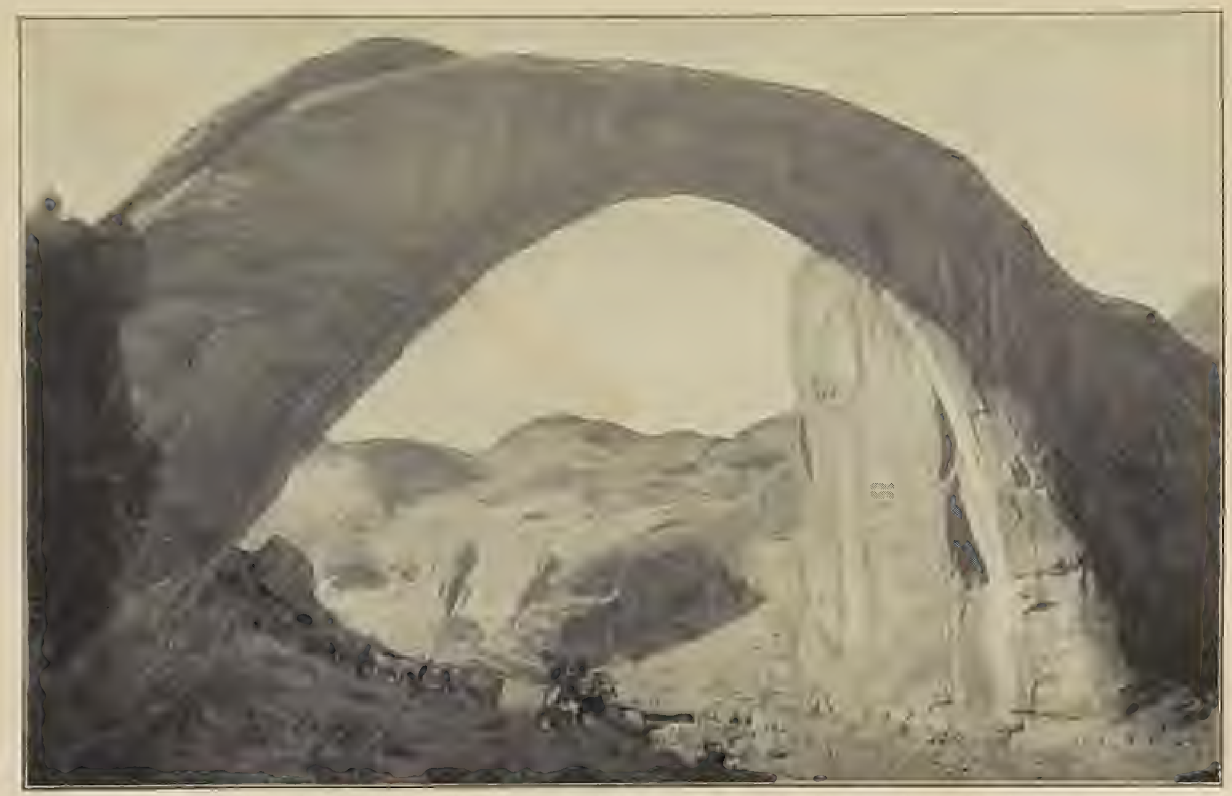
THIS PEAK IN THE SIERRA MOUNTAINS IS BEING LEVELLED DAY BY DAY AS CHANGES IN TEMPERATURE CRACK THE ROCKS AND CAUSE THEM TO SCALE OFF.

each levelling. The result is as definite and sure as that the castles of sand built by children upon a beach at low tide will be obliterated by the returning sea.

It is, as a matter of fact, the sea that will level them, to some extent by these same waves dashing upon the coast, but chiefly in a very different fashion. It is the sea heated into vapor by the sun and blown inland to fall as rain upon rock and soil, washing their substance away, invisibly, insistently. Water is the great leveller of the earth's surface. As rain or snow or ice and aided by the force of the wind and the chemical action of the air, it is estimated to have swept away in the life of the earth the equivalent of twenty mountain ranges the height of the Rocky Mountains or the Swiss Alps.

What has built these generations of mountains? What are the forces corresponding to the children's shovels that throw up the castles of sand? They are the gradual adjustments of the earth's rock masses which, slowly moving, compel its crust to shift and crack and fold till it is wrinkled like the skin of a dried apple. They heave sea-bottoms high in the air, and drown continents beneath the waves; or squeeze great folds of the crust thousands of feet aloft as mountain ranges; or pour forth molten rock through long cracks or fiery gullets.

Thus it is the sun, drawing aloft the waters of the sea, that controls the changing face of the earth. Not only is this planet the child of the sun and circles through space, held firmly in leash of it, but the surface of the earth is still, day



THE RAINBOW NATURAL BRIDGE, NEW MEXICO, WAS MADE BY EROSION.

following day, moulded by the colossal power of the sun, driving its rays through 93 million miles of cold, empty space. Through the long ages the sun has ploughed and ploughed again the soil of its satellite. Every harvest of living things upon the earth, from the simplest sponge to man himself, is dependent upon the heat and light of the sun for existence.

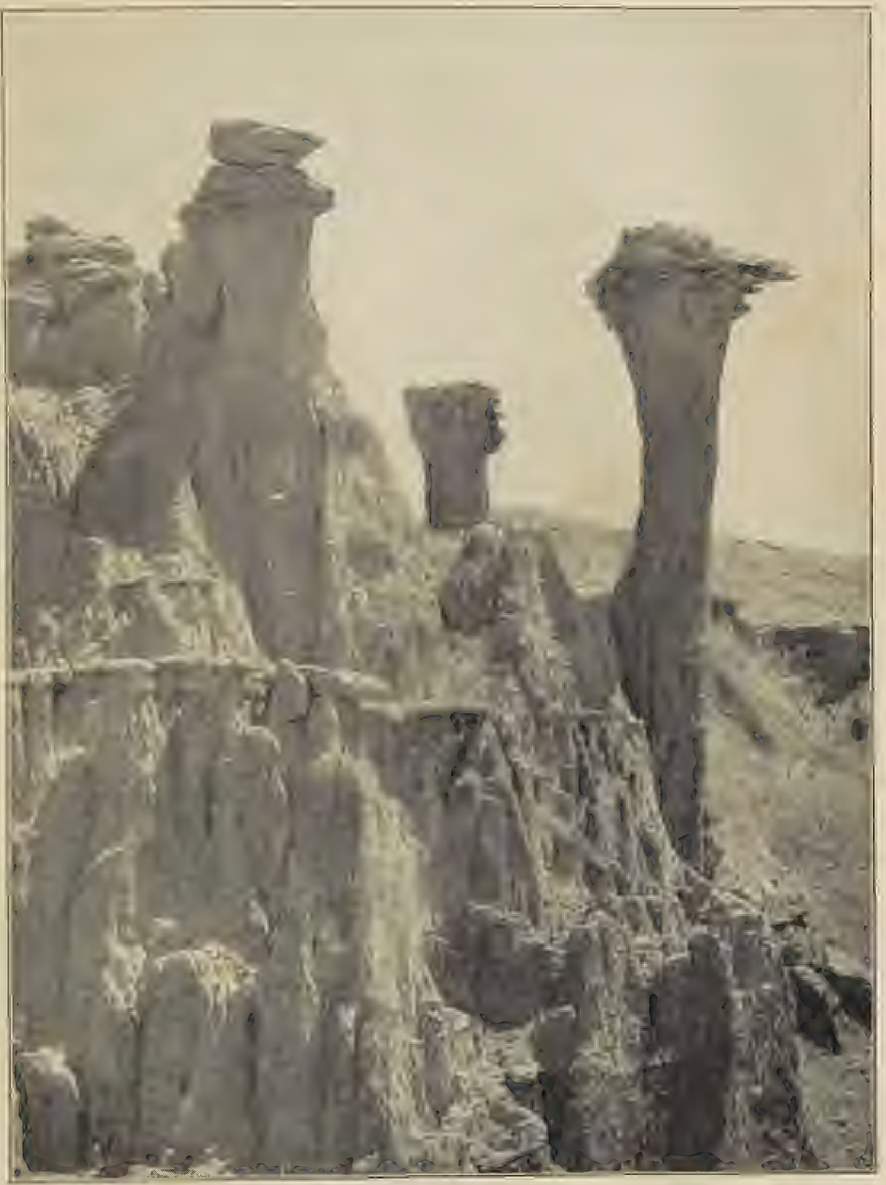
The wearing down of the land by the weather is a monotonous routine that never ceases. Not so the upthrusting of the crust. This has come periodically, has been accomplished swiftly—within a hundred thousand years or so—and after the convulsions have ended the earth has settled down to periods of rest often long continued, lasting for millions of years. Each great upheaval has left the earth mountainous and rugged. This state is a period of youth. Then through the millions of years the rain and the winds eat away the great hills, rounding them off, sweeping their débris down the rivers to the sea. The lands grow old, until finally they become low-lying wrecks of their former greatness.

Man lives to-day upon lands that are, in this sense, fairly young. Much of the earth was but recently violently upheaved, geologically speaking. That is to say, its greatest mountain ranges were folded aloft only a few million years ago, and the rain has but begun to carve them. Never, perhaps, was the scenery of the earth as noble and varied as in this era of man.

But if the features of our earth have been rejuvenated, the material of its surface is old as old. It has been used over and over again. The very bit of earth on which one stands may have played its part on distant snowy summits, have travelled thousands of miles by brook and river, have lain in the ocean slime thousands of feet beneath the surface—not once but many times.

The fashion in which geologists have reconstructed a connected story out of this confusion offers the most absorbing page in science. Geology is the greatest detective story that has ever been written. When the waves of the sea wash away castles of sand on the beach, they leave no trace behind. The sand sinks back into its bed, and at the next low tide the beach is as if the shovels of children had never touched it. Fortunately for the geologists, the levelling of the mountains works differently. When the soil worn away by the rain finally reaches a river-mouth, it sinks and spreads out in a thin layer on the bottom of the sea, that thickens with the years. This in time hardens, perhaps changes its chemical composition; at any rate, it forms a distinct layer or stratum of rock (called sedimentary rock) which there is no mistaking. Thus in a few million years a rugged upstanding range of mountains a thousand miles inland may lie as a delta beneath the sea, a thin layer of wholly different rock.

If these sediments remained at the bottom of the sea, man would not be much the wiser for them. But the surface of the earth has again and again been thrust or folded high in the air. (Fish once swam over the Rocky Mountains.) The earth



WIND AS WELL AS WATER WEARS AWAY ROCKS.

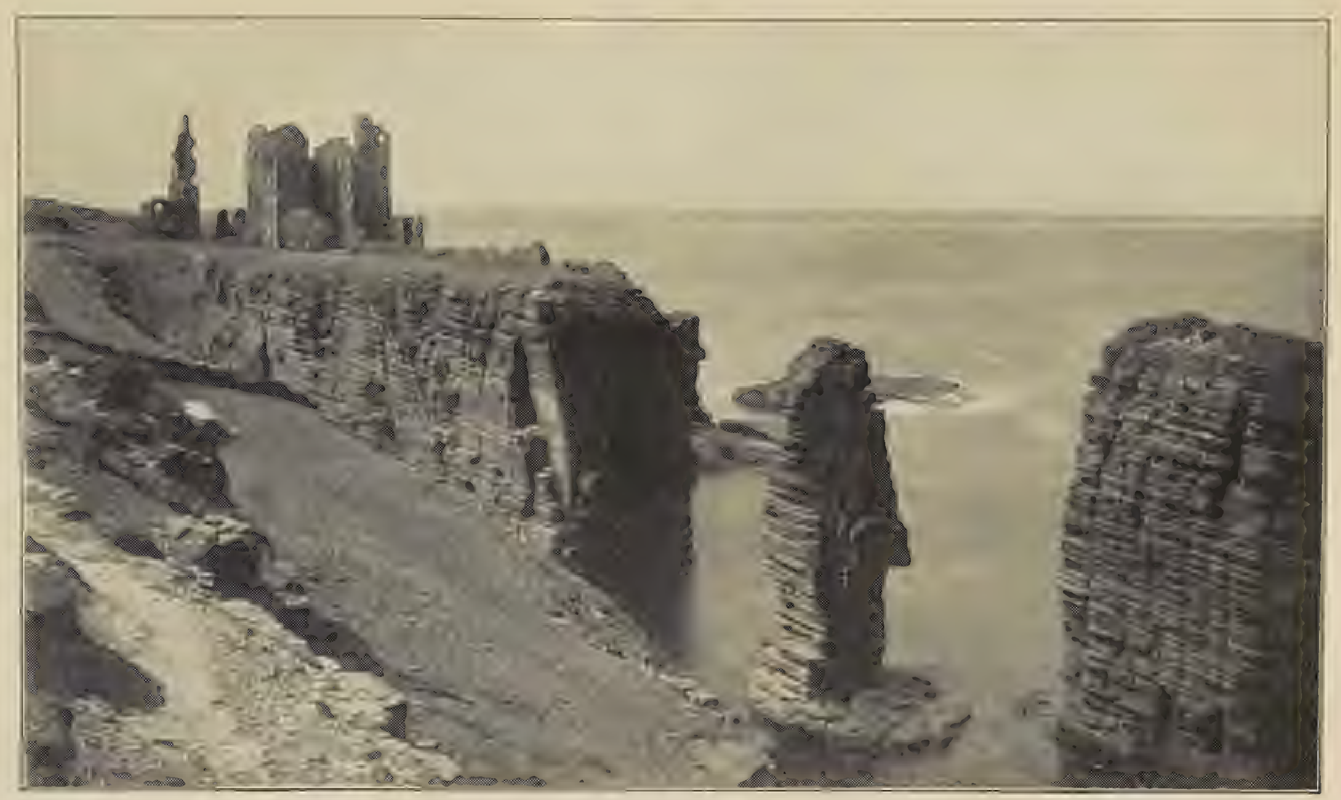
These Ostrich Rocks in the bad lands of South Dakota have been carved by the constant abrasion of sand carried by the wind.

after burying beneath the sea its castles, that is, its mighty mountains, sometimes lifts the record of their scattering for man to study. It should be noted, too, that rivers sometimes deposit strata above sea-level, in lakes or at the edge of deserts, for example, or by flooding over an alluvial plain.

Here are clear and direct clews. To reach such strata backward, beginning at the bottom stratum, which was obviously laid down first, is to have a rough account of the mountains of which they are the distant deposits. Unfortunately this record, sadly incomplete, is confused in countless ways. Strata were laid down only at the mouths of ancient rivers, at the edge of vanished continents. They cannot therefore give a uniform record the world over. Nowhere did there ever exist a complete sequence of these deposits. Geologists must find the deposit of a small mountain and a million years here, a great range and ten million years there, and piece them together as best they can.

Two things have aided. First is the fact that the surface of the earth has not heaved up and down restlessly like the waves of the sea. It is the modern belief of geologists that certain areas have generally tended to push up and certain others to sink down. The continents have changed shape frequently and completely, flooded by shallow seas; but certain portions of them called "shields"—Labrador, for example—have long been above sea-level. And the deeps of the oceans have probably always been under water. Why this is so is not understood, but the effect is obvious. The movements of the earth's surface have been much simplified, and there have been deposited in certain spots, which for ages were slowly sinking river-troughs, long series of sediments. In the Appalachian Mountains (long under the sea) there lie enough sedimentary rocks to make, if placed vertically, a depth of thirty miles. In the Rocky Mountains it is estimated that there are twenty miles. Impossible? Go out and watch any muddy river sweeping silently to the sea. It has been calculated that the River Thames in England carries away enough solid rock every year to build for London a new St. Paul's Cathedral. On the same basis, the Mississippi carries away a thousand cathedrals a year, most of which is deposited in a fan-shaped delta of no great size. These are only rough estimates. But one can imagine what enormous depths these deposits would total in the course of millions of years.

The second great aid of the geologist is the fossil. These skeletons of ancient animals preserved by the chance of burial in a favoring rock formation are a history in themselves. They tell not only the story of life but they shed a flood of light upon the changing surface of the earth. For the geologist a fossil is first of all a date carved by nature—not an exact year, but a general period. Knowing under the theory of evolution the general course of animal development, scientists can often arrange a series of fossils in exact order of time. They thus fix approximately the age of any stratum in which these fossils occur. A fossil is, not less, a self-registering thermometer and a photograph of the passing scene. Was



SEDIMENTARY ROCK ON THE COAST OF SCOTLAND.

The waves have widened cracks in the rocks and worn away whole sections.

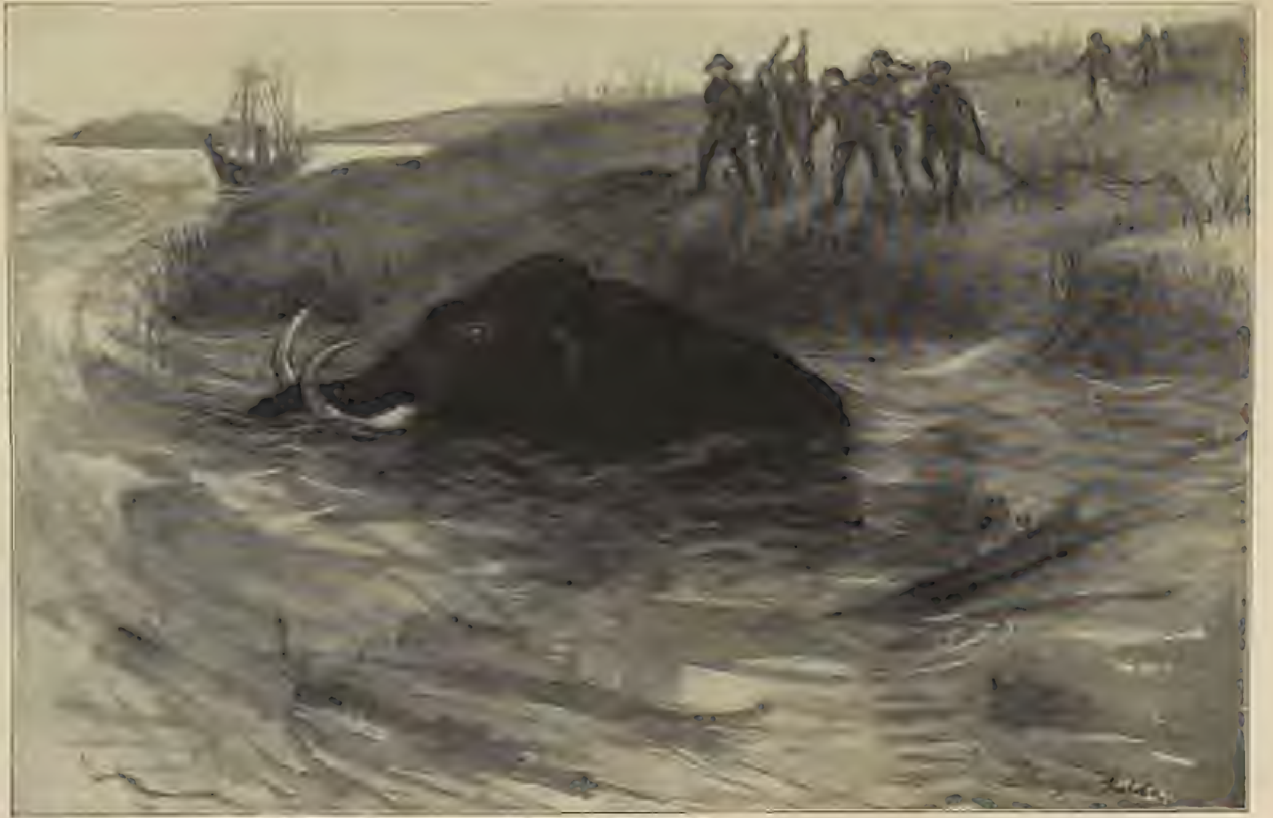
the sea in which, millions of years ago, this fish swam salt or fresh, shallow or deep, hot or cold? Who were his companions and what was their fate? Such questions can often be answered by the paleontologist, thanks to the patient observation and study of a century or more.

If only science possessed these silent witnesses, revealing so much by their presence, for every period of time and every condition of life! Unfortunately, this preservation of a skeleton over millions of years is a long chance. It can happen only under the most favorable conditions. Chiefly it is certain sedimentary rocks, formed under water, above all limestone, that contain fossils; and therefore it is chiefly marine animals which are preserved—or animals like reptiles living near rivers or bays.

Rarely a chance of a different nature preserves an animal entire; a great woolly mammoth has been dug out of the icy ground, called tundra, of northern Siberia, with the hide and flesh and hair intact after thousands of years, preserved by a natural cold storage. There has also come down an occasional footprint left in stiff mud (later changed to sandstone) by some great animal that drank his fill and passed on. For the geologist such a mark, millions of years old, is as full of meaning as a fresh spoor to a hunter of to-day. Only his quarry is an animal perhaps so long extinct that the eyes of man have never seen it alive.

Every one is vaguely familiar with the general facts about fossils nowadays. The word has even passed into the slang of the period. The idea is part, a tiny detail, of that great body of scientific truth which is the modern heritage. But it is only within the last two hundred years that the nature of fossils has been clearly understood. Fossils are common enough; they have been observed for several thousand years. The Greeks speculated keenly about them, but lacked the scientific basis to determine exactly what they were. Then followed that long pause of the human intellect, lasting nearly two thousand years, which is one of the most striking facts of historic times. As late as the sixteenth century the most fantastic explanations of them were put forward. They were freaks of nature, or formed in the earth under the influence of the stars. The versatile mind of Leonardo da Vinci, the great Italian painter of the fifteenth and sixteenth centuries, was one of the first to guess what they really were.

The Grand Canyon of the Colorado River shows all these clews in their simplest form. Here the strata have not been tilted on end so that a cross-section is exposed at the surface—like a slice of layer-cake turned on its side—the commonest form in which strata afford a chance for study. They lie much as they have always lain, and one sees them only because the Colorado River has obligingly cut its way a full mile down from the surface and exposed their cross-sections to that depth. One can descend to the bottom of the gorge on a mule in three or four hours. In so doing, one will have crossed strata which it took hundreds of millions of year to deposit; and one will, at the bottom, have reached the very

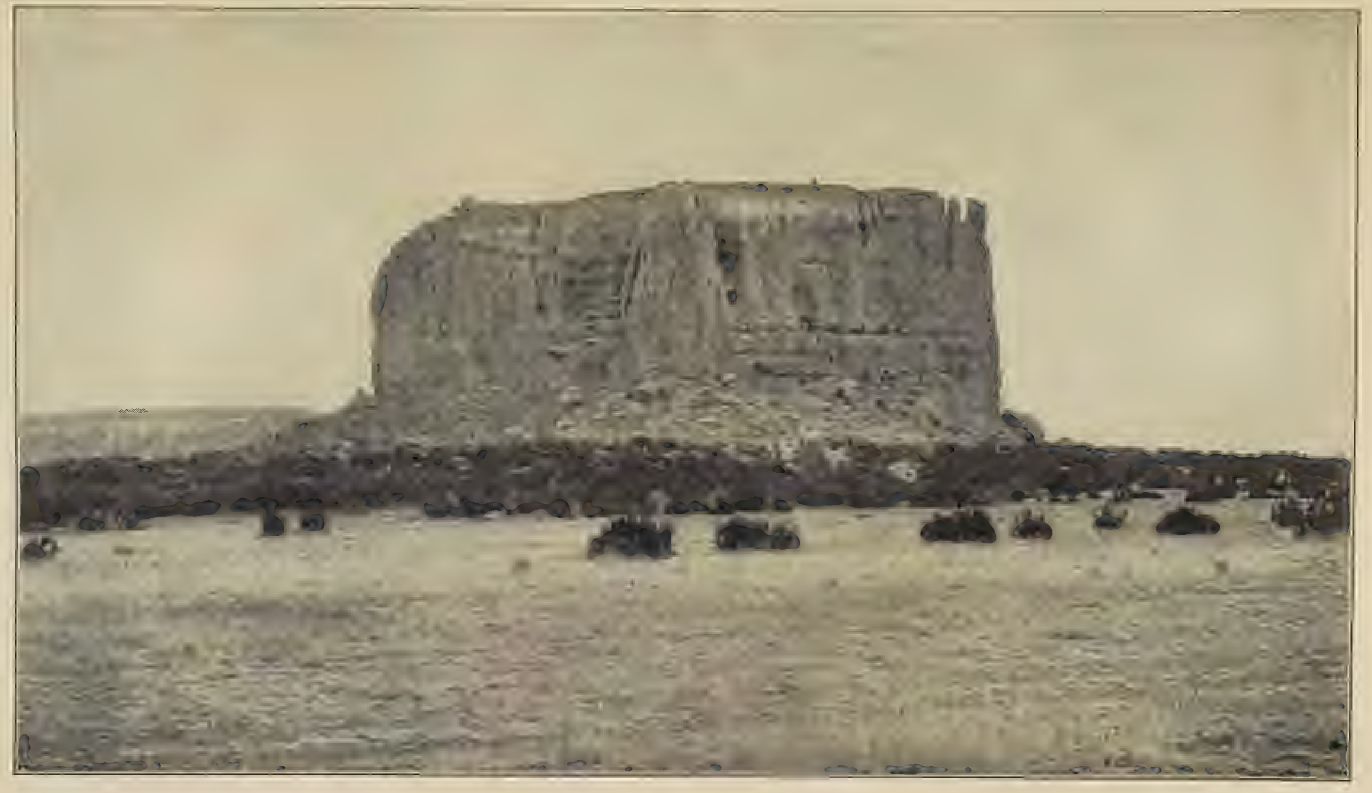


From W. T. Hornaday's "Tales from Nature's Wonderland."

THE FROZEN MAMMOTH OF THE INDIGIRKA RIVER, SIBERIA.

The front feet are free, but the hind feet are still frozen to the bottom.

From a drawing by E. Rungius Fulda after the story of an eye-witness.



THE ENCHANTED MESA, NEW MEXICO.

A cap of hard rock resisted erosion and left this butte standing alone after the rest of the land had been worn away by the action of running water.

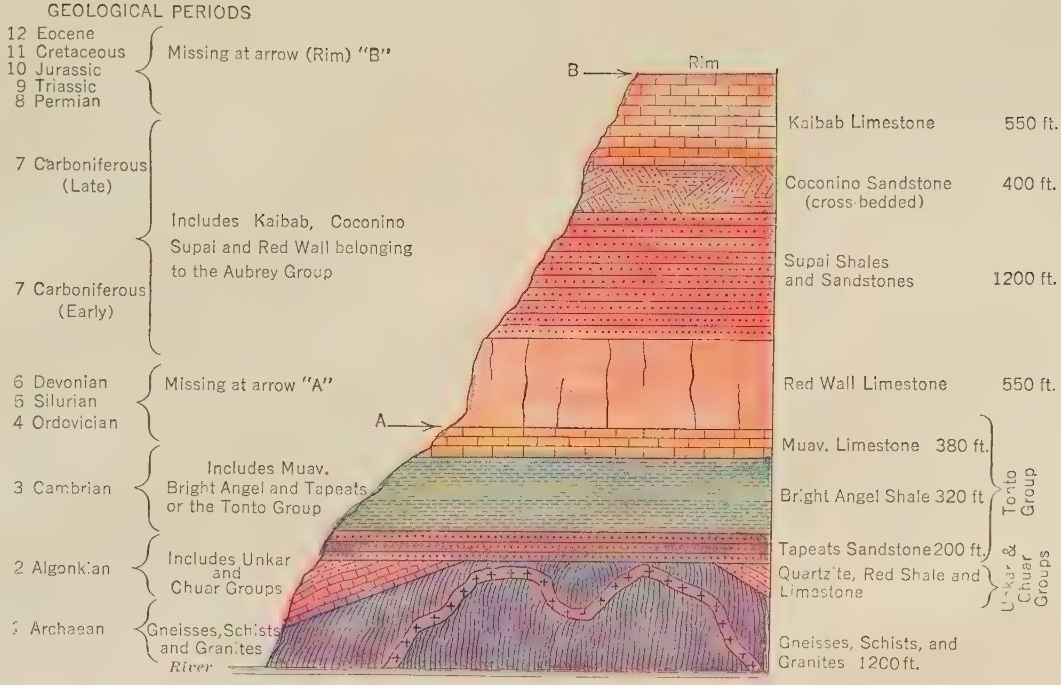
beginning of geologic time, one of the oldest rocks known.

The main features of the rock formations stand out unmistakably. They give the canyon its strange beauty. The narrow gorge at the bottom is a mass of granite and other dark rocks showing no sign of strata—molten, or igneous, rock, in fact. Just above appears a set of strata much tilted. Above these and extending clear to the surface are level terraces showing clearly a long series of strata, all level and all laid down as neatly as if done by hand. It is the variety of these upper strata, varying greatly in composition and in color, that gives the canyon its splendor. One odd detail, a significant clue, may be noted in passing; the tilted strata and the igneous rock reach a common level; that is, they together make a flat floor upon which the level strata rest.

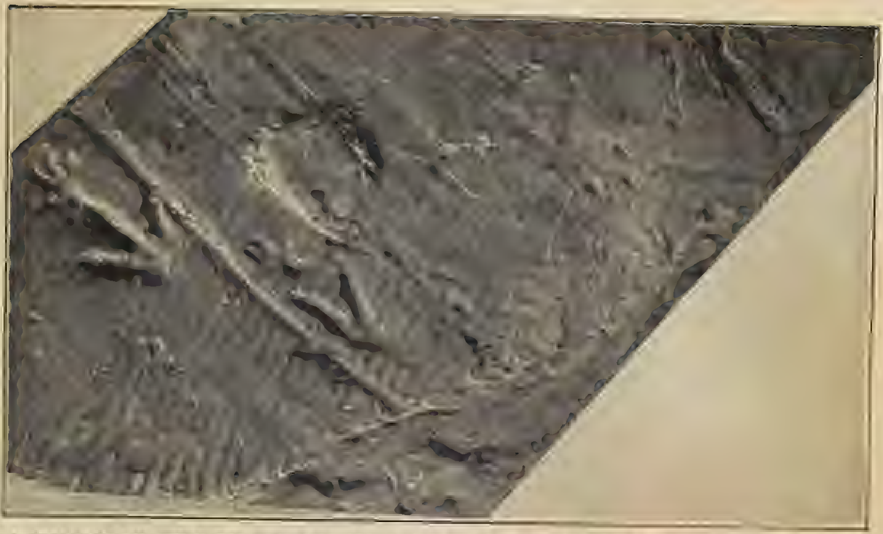
Even an amateur detective could draw some interesting deductions from these obvious clews. The geologist has many other facts to help. The fossils, for example. Moreover, he can carefully compare the fossils of these strata with corresponding series of strata in the United States and elsewhere.

He finds only slight traces of fossils in either the dark rock at the bottom of the gorge or the tilted strata resting upon it. Just what life did exist at this time will be discussed in the next chapter. At any rate, in the seas then covering the earth there lived no animal with sufficient bones or shell to be preserved in quantity. Crossing the level surface formed by these two forms of rock, and reaching the lowest of the level strata, the geologist finds the first considerable number of fossils. They are primitive clams and periwinkles and so on—shelled animals. Next above come strata with fishes as well; and in the topmost strata there appear strange amphibians and the first reptiles. And there the record ends. Many more strata doubtless once covered the plateau through which the canyon runs; they have been worn away by the rain, and geologists must look elsewhere for clews upon which to base the remaining chapters of their history. Just consider what is missing: there is no trace of great reptile, of bird, of mammal. When the last of these rocks was laid down beneath the sea, the fish still ruled the world, and life had but just begun to climb out upon the dry land. The detailed story of the Grand Canyon as reconstructed by the geologist runs as follows:

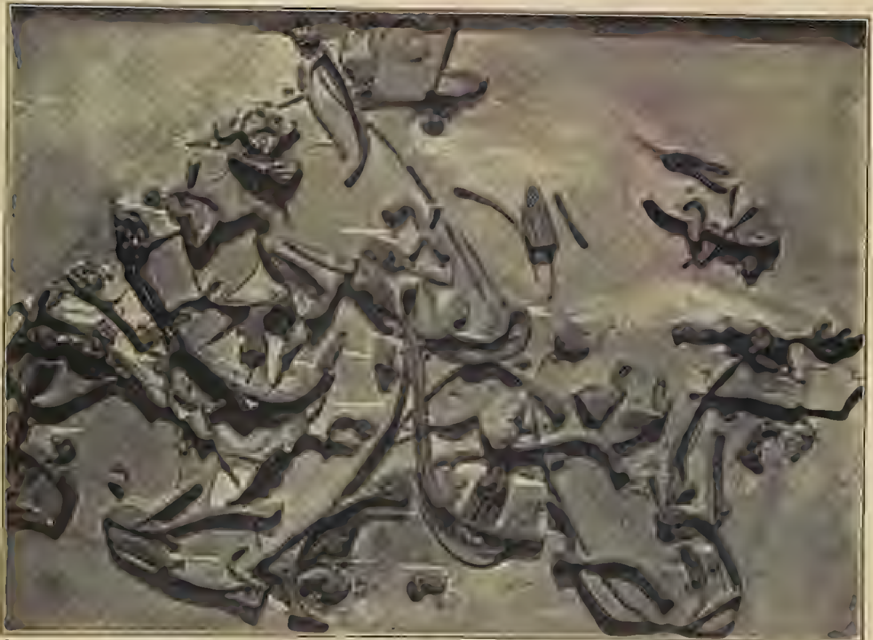
The dark rocks at the bottom are a part of the oldest crust of the earth that has been preserved. They are molten rock which probably poured up through rocks now vanished. Later they were terribly crumpled and crushed as the earth shrank in size; their surface must then have been extremely rugged and mountainous. But rain slowly, after untold ages, wore away this area till it lay a level plain. This has an extraordinary interest, for it is a piece of the oldest surface of the earth that has come down to us—preserved as were the fossils by the chance of an enduring burial. The whole dark mass then sank below the sea, and there, layer by layer, the first of the tilted strata were deposited upon it; only, the surface and the tilted strata must then have been nearly level,


GEOLOGICAL PERIODS
12 Eocene
11 Cretaceous
10 Jurassic
9 Triassic
8 Permian
Missing at arrow (Rim) "B"
7 Carboniferous (Late)
Includes Kaibab, Coconino Supai and Red Wall belonging to the Aubrey Group
7 Carboniferous (Early)
6 Devonian
5 Silurian
4 Ordovician
Missing at arrow "A"
3 Cambrian
Includes Muav. Bright Angel and Tapeats or the Tonto Group
2 Algonkian
Includes Unkar and Chuar Groups
1 Archaean
Gneisses, Schists and Granites
River
B
Rim
A
Kaibab Limestone 550 ft.
Coconino Sandstone (cross-bedded) 400 ft.
Supai Shales and Sandstones 1200 ft.
Red Wall Limestone 550 ft.
Muav. Limestone 380 ft.
Bright Angel Shale 320 ft
Tapeats Sandstone 200 ft.
Tonto Group
Quartzite, Red Shale and Limestone
Unkar & Chuar Groups
Gneisses, Schists, and Granites 1200 ft.

A CROSS-SECTION OF GRAND CANYON STRATA AT EL TOVAR.



A DINOSAUR TRACK FOUND IN A ROCK IN WEST ORANGE, NEW JERSEY.

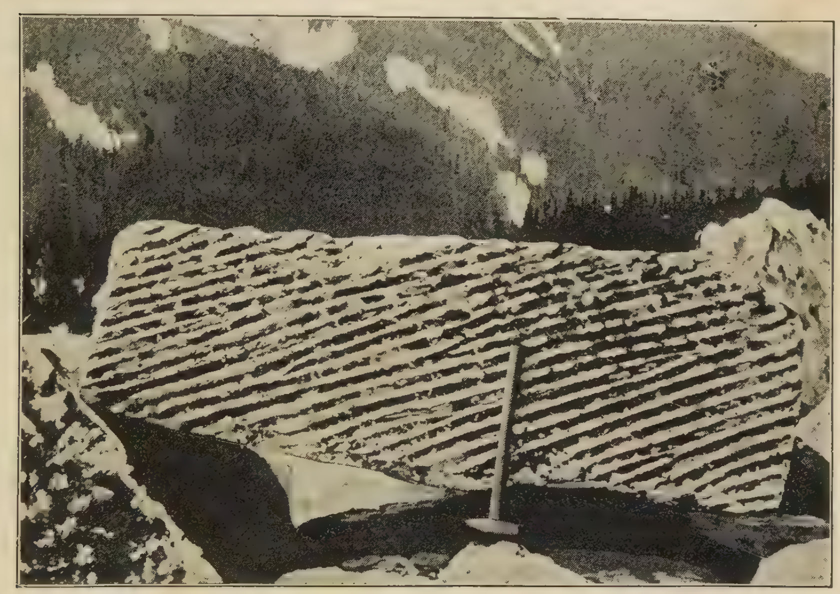


Courtesy American Museum of Natural History.

A LIMESTONE SLAB FROM ILLINOIS CONTAINING FOSSIL CRINOIDS, OR SEA-LILIES.

Crinoids were the most abundant form of sea life during the early Carboniferous era, many millions of years ago.

for marine sediments do not form on a steep slope. The upper layers of these tilted strata are ripple-marked and suncracked, and therefore must have been deposited above sea-level, perhaps as a river delta or at the edge of a desert. How did they become tilted and how was the level surface formed? After millions of years the whole floor, granite and sedimentary rock together, was folded high in the air in a great mountain range and exposed once more to long ages of weathering, which finally again planed it off to a dead level.



RIPPLE-MARKS ON SANDSTONE BEDS AT THE SUMMIT OF THE SELKIRK MOUNTAINS, 7,000 FEET ABOVE SEA-LEVEL.

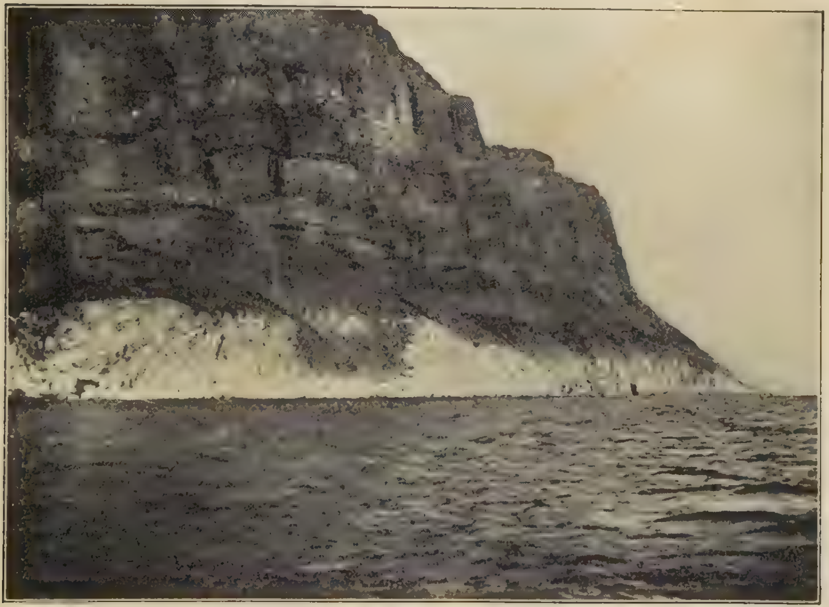
These beds, once laid down under water, have been tilted into a nearly vertical position. The hammer is two feet long.

A colossal length of time is represented by the weathering and deposit of these early rocks—not less than half the whole geologic life of the earth, it is believed. That is to say, at least 250 million years. It forms one of the four eras into which geologists divide their records. They call it Archean, and it may be thought of as corresponding to the prehistoric period of the text-books of human history. For it is the period before fossils, and these are to the geologists what written records and history are to the historian of man.

Above this line (at which begins a clear record of fossils) stands a long record of quiet growth. Clearly the whole area must have again sunk below the sea and remained there undisturbed for many millions of years. The strata remaining carry in fact almost through the next geologic era, during which ancient forms of life were developed in the sea down to and including the amphibians. With their weakness for long, hard names, the geologists call it the Paleozoic era, which means nothing more or less than the era of ancient life. Roughly speaking, this era lasted half as long as the preceding; that is to say, a minimum of 125 million years.

The last quarter of geologic time, forming two whole geologic eras, is thus unrepresented in the Grand Canyon—the mediæval and the modern, or the Mesozoic and Cainozoic in geological parlance. There is a certain suggestive parallel in the name mediæval for this succeeding era; for, as will be seen, it witnessed the rise of those strange and mighty animals the dinosaurs, that is to say, "terrible reptiles," long since extinct, and as alien to the modern world as much of mediæval thought is difficult for the modern mind to comprehend. The modern era begins, logically enough, with the rise of the great mammals and the modern forms of life culminating in man.

One need not climb to the bottom of the Grand Canyon to find the earliest known rock, the Archean granite and

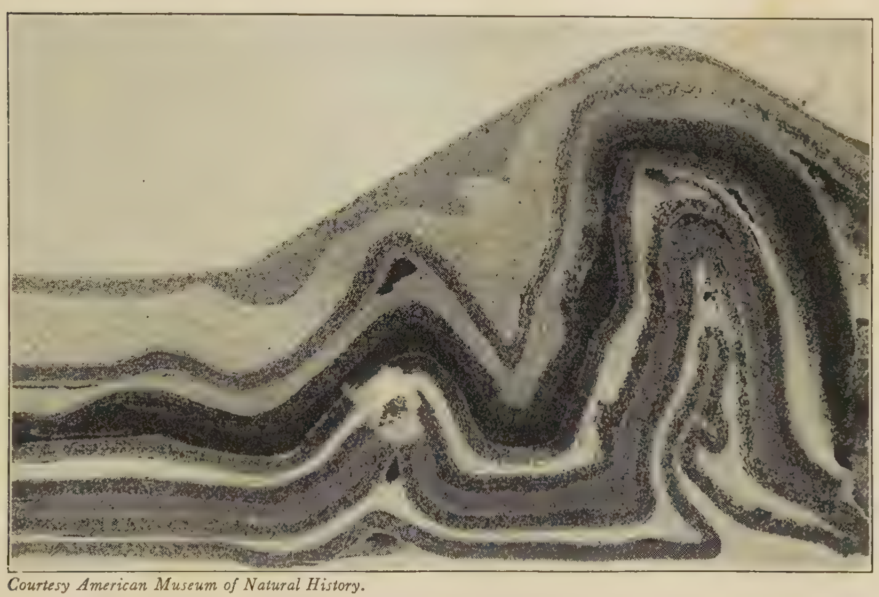


THE LIGHT-COLORED ROCK AT THE BASE OF THIS CLIFF IN LABRADOR IS ARCHEAN GRANITE, UNDERLYING MUCH YOUNGER SEDIMENTARY ROCK.

the sedimentary rocks without fossils. It rises to meet one at the surface over a considerable portion of the globe—one-fifth of the land area, it is roughly estimated. That is to say, whatever sediments once covered this rock have in these regions been washed clear away. It is only because the Grand Canyon is young that Archean rock is there buried; the covering will be washed clear away in a few million years. In North America the chief area of this rock begins in Labrador, runs southwest into northern Wisconsin, including the Lake Superior iron region, and thence turns north to the Arctic Ocean. Granite, twisted and torn, forms a large portion of this rock. But not all granite is Archean, it should be understood; molten rock, of which granite is typical, has poured up from the heart of the earth in every era. The Archean rock is identified in the Lake Superior region at the surface exactly as it is identified at the bottom of the Grand Canyon —by the fact that where it runs below the surface and disappears, the rock immediately resting on it is exactly the early sedimentary rock containing the first primitive fossils which rest upon it in the Grand Canyon.

These early formations are greatly confused and it has been a difficult task to classify them. Much important work is now under way. The Old Archean era is being divided and renamed. But no generally accepted classifications have been reached. There is still some question as to just what the Archean igneous rock was. When first discovered, it was taken to be a part of the first molten crust of the earth. The weight of opinion is now strongly against this view. It is felt to be extremely unlikely that any trace of this crust will ever be found. As for the granite at the bottom of the Grand Canyon and covering Labrador, etc., in great sheets, the tendency is to regard it as produced exactly like more recent igneous rock; that is to say, it welled up from below between ancient strata of sedimentary rock long since vanished.

There have been many ingenious speculations about the composition of the interior of the earth, but about the only fact yet established is that it is much heavier than the crust.



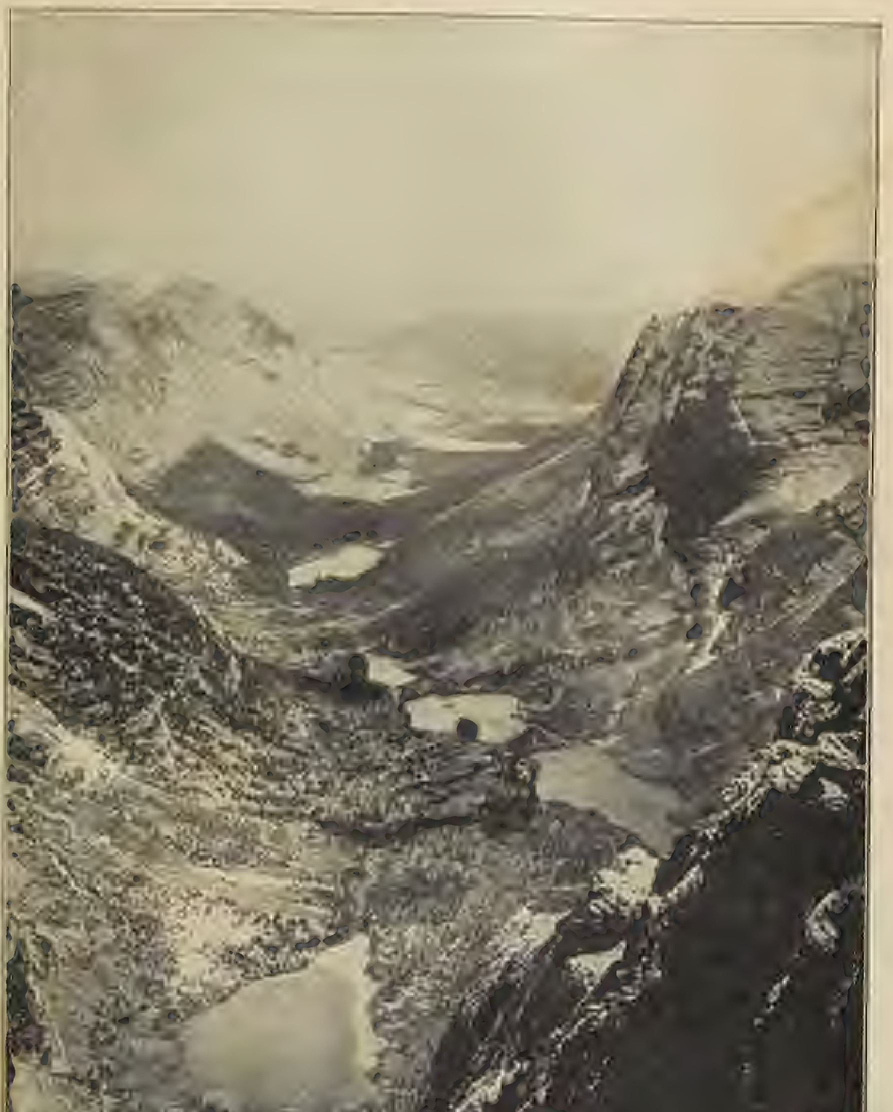
Courtesy American Museum of Natural History.

THIS MODEL SHOWS A CROSS-SECTION OF A VOLCANIC ERUPTION.

The older view went on to consider that the core of the earth, still very hot, was slowly cooling, and that it was this cooling which caused the earth to shrink and the crust to crack and fold. It is still believed by some scientists that the earth is shrinking, but whether cooling is the cause has been seriously questioned. One had best consider this whole question of interior temperature as still unsolved. As a fresh complication there enter here as there enter into the question of the heat of the sun the new discoveries of radioactivity. Just what this break-up of certain atoms means the chemists do not yet know. The possibilities will be seen in some detail when the story of modern science is reached. For the present it is enough to note that here, as almost always in science, a great increase of knowledge has served to reveal yet greater problems and mysteries. The inside of the earth may even be growing hotter instead of cooler.

As for the surface of the earth, there is more satisfactory evidence once one gets beyond that initial stage already discussed. Whether the earth's surface was molten or not at completion, it did not stay thus hot long. Least of all has it steadily cooled down to the present time. The prevailing view now is that the climate of the earth has been through great periodic shifts from hot to cold and cold to hot, but without any general tendency one way or the other. If one considers that the climate of the earth has been generally mild with brief interruptions of great cold one will probably not be far from the truth.

What produced these times of extreme cold? Will they occur again? If so, how soon? It would be easy to give a long series of possible answers, but the fact is that science does not know. The last age of great cold that covered northern America and northwestern Europe with solid ice hundreds of feet deep and dumped its loads of boulders and clay as the ice melted is not far distant, geologically speaking. It occurred within the last period (the Pleistocene) of the mod-



A VALLEY IN GLACIER NATIONAL PARK WHICH HAS BEEN WIDENED BY THE SLOW PASSAGE OF A GLACIER.

The chain of lakes was also formed by its gouging action. This glaciation occurred during the Pleistocene.

ern (the Cainozoic) era. That is to say, these ages of cold all occurred within the last million years or so, and the last ended not more than 25,000 to 50,000 years ago. That may be a long enough interval, humanly speaking; all historic time does not go back much beyond 5,000 years. It is close enough to have a very real interest for man of to-day.

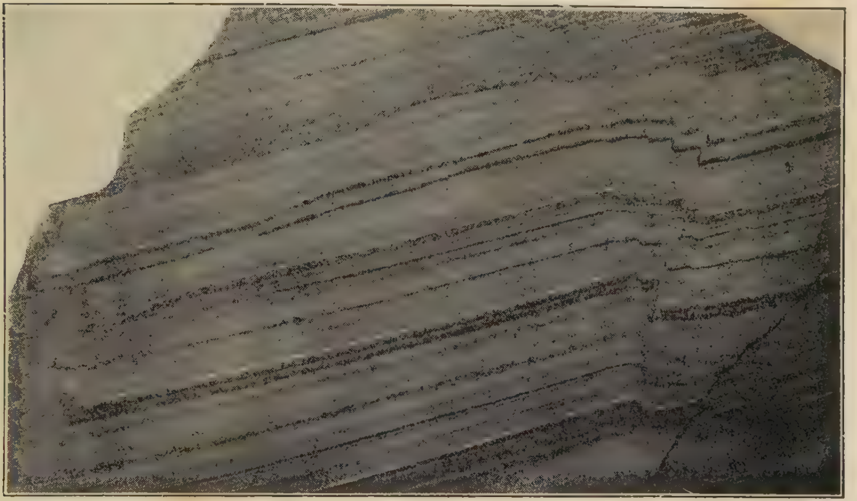
He need have no fears for himself or his descendants for many, many generations—such extreme cold approaches slowly, imperceptibly, over hundreds of years. But what of the civilization that he is part of, that every one is helping to build? How much of it would survive another great ice age? It will appear in a later chapter that primitive man first developed upon the earth during this ice age, and survived periods of great cold, probably retreating safely to warmer areas before the downcoming glaciers. Would the marvellous and elaborate civilization of modern man fare as well? Who can help but wonder?

So it is of real interest to put the question to geologists whether in 25,000 A. D. New York and Paris and London will return to the climate of Greenland that they had in, say, 25,000 B. C. Their answer must be, as suggested, that as yet they have not the slightest idea. Until the causes of glaciation are better understood it is idle to base a guess upon science. Here again science has gained a wealth of extraordinary wisdom. It has shed a flood of light upon those questions as to the origin and growth of the world which the ancient myths sought to answer. But in so doing it has revealed other problems, it has raised unsuspected doubts and possibilities that it as yet has not begun to clear up. Few men believe today that the world is coming to an end at a fixed day or soon, as was a common belief in the Middle Ages. No man can escape the fact that ice not so long ago covered a mile deep much of the area of our present highest civilization and, so far as science can say, may again cover it.

The question of time, of the age of the earth, and the length of years assignable to each geologic area, has already come up. It can now be understood how impossible it is for the geologist to estimate his eras in accurate figures. Of the order of events, of the proportions of elapsed time in each great era, he can form fairly clear ideas. He cannot with any certainty state his ideas in an exact number of years. No geologist pretends to, and the figures here given must be understood as merely rough estimates. They will give a rough limit, a maximum and a minimum, between which one can perhaps make that tremendous stretch of time a little more vivid.

The deposit of sedimentary rocks is the first source of a time schedule. Geologists have measured carefully the existing sedimentary rocks. They have also endeavored to estimate the length of time which a river takes to lay down a given kind of sediment. But the factors making for uncertainty are great. The time needed to deposit a rock is most difficult to estimate.

When a country is young, recently upheaved that is, the streams are steep, the action of rain is violent, and the land is swept into the sea rapidly. (The ancient deposits often show this condition clearly in the coarse sandstones.) As the hills are rounded off the process slackens until as the continents approach sea-level erosion all but ceases. Moreover, the deposits vary greatly over the earth, as has been seen. Taking all the sedimentary rocks in order, assembling them in a column each at the greatest thickness at which it anywhere occurs, geologists estimate the total depth of deposits at over sixty miles. The maximum thickness of a stratum naturally extends over a small area, to wit, the under-water delta of the rivers which happened to record the maximum force of ero-



STRATIFIED ROCK, OR ROCK MADE BY SEDIMENTATION, MAKES UP THE LARGER PART OF THE LAND SURFACE OF THE EARTH.

Its arrangement in layers is plainly shown here. The waves at the right are caused by some earth disturbance which distorted the sandstone.

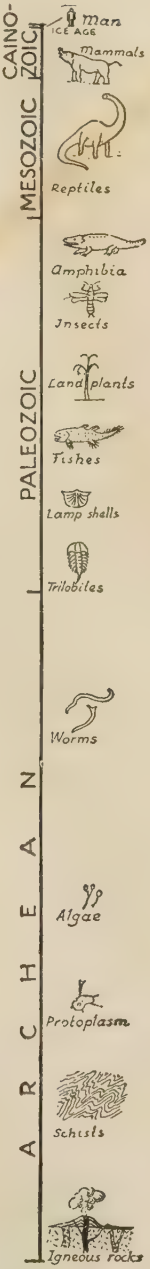
sion during the period in question. The longest record found in any one region is twenty miles—in the Appalachian Mountains. The total depth of sedimentary rocks in any one spot is usually under a mile. In the Grand Canyon, for instance, there are only about 4,500 feet of the level strata (the Paleozoic); in the Appalachian Mountains there are not less than eight miles of these same strata identified by composition and by fossil life within them. This means simply that the sediments of this long period happened to be deposited more rapidly and completely at the river-mouth which was later raised into the Appalachian Mountains than at the river-mouth which was later raised into the plateau of the Grand Canyon. For a final difficulty, this geologic column is by no means complete. It is added to constantly as research proceeds. Probably it never can be completed because of the sediments which lie hidden beneath the seas. Perhaps one-half of the total has now been recovered; but that is only a guess. There are yet other complications, and no basis for accurate figuring exists.

But certain broad conclusions can be drawn. During the Archean era more sediments were laid down than in all three eras since. Geologists consider that there is warrant for estimating roughly that at least one-half of all time elapsed in this prehistoric age before fossils, in any considerable numbers, appeared. The ratios of the remaining three eras have been similarly estimated on the basis of the deposits within them. The Paleozoic comes next in length, occupying almost a third of the life of the earth. The Mesozoic is a little more than a tenth. The Cainozoic is barely a twentieth.

When one seeks to express the length of these eras and the total life of the earth in years one faces an even higher degree of uncertainty. Most of the estimates in years based exclusively on the time required for the formation of the sedimentary rocks have been under 100 millions years. Yet distinguished geologists have estimated this required time as high as 400 million or even 800 million years.

These estimates based on sedimentary rock can be compared with estimates reached by other methods. One of these is based on the time required for the formation of the salts in the ocean. The primitive waters of the earth were fresh, it is believed, and the salt was slowly washed out of the rocks. Most of the estimates reached by this method run close to 100 million years. Yet a recent calculation gives an estimate of between 210 and 340 million years.

All earlier methods of calculation have of late been overshadowed by conclusions drawn from the newly developed theories of radio-


CAINO-ZOIC
MESOZOIC
PALEOZOIC
ARCHEAN
Man
ICE AGE
Mammals
Reptiles
Amphibia
Insects
Land plants
Fishes
Lamp shells
Trilobites
Worms
Algae
Protoplasm
Schists
Igneous rocks

TIME LINE SHOWING RELATIVE LENGTHS OF GEOLOGICAL ERAS.

activity. Physicists now believe that a transmutation of some chemical elements of matter is taking place as a result of radioactivity, that uranium, for example, slowly produces lead. The rate of change can be estimated and so can the amount of lead in the early geologic formations. While such calculations are rough, a number of independent estimates based upon studies of different regions and different elements all point to a very long length of time, in the neighborhood of a billion 400 million years, as the age of the earth.

These figures are sufficient to show how completely open minds must be kept on this interesting point. In a general way it may be said that the trend of estimates has been upward. Lord Kelvin, the British physicist, calculated in 1862 that the earth might be only 20 million years old. This was a view exceedingly difficult to square with the theory of evolution, which requires a vast period for the gradual development of life. Later discoveries have tended to disprove the calculations of Lord Kelvin, and to give a far longer period. If one takes 500 million years as a probable minimum and a billion 500 million years as a probable maximum, and adds that recent views tend toward the higher figure, one will express roughly the prevailing scientific thought of the day.

This whole question of the age of the solar system and its possible life in the future has been revolutionized in the last few years by the discovery of radium and radioactivity, already referred to. The fact that certain elements are breaking up and changing into other elements, giving off heat as they do so, supplies an entirely new and unsuspected source

LORD KELVIN.

of energy in the universe. Heretofore the life of the sun had been calculated on the theory that its continuous heat was the result of shrinking, and it was possible to calculate roughly how long this process had lasted and might be expected to continue. Now the whole question of the sun's heat as of the earth's heat is transformed. No accurate estimates are as yet possible, for the study of radioactivity is still young. But it seems safe to assume that this new source of energy will account for an extremely long past and provide for an indefinitely long future.

3. THE FOUR GEOLOGIC ERAS

The four great eras of geology, Archean, Paleozoic, Mesozoic, and Cainozoic, have already been described. These divisions are simple enough in their plan but they have been made absurdly difficult for the ordinary reader by the jaw-breaking names that have been attached to them. The subdivisions of these eras, called periods, have names equally confusing. Some of them take their names from the place where typical formations were first found—Devonian from Devon in England, for example. But Carboniferous and Cretaceous describe formations, coal-bearing and chalky; and Pleistocene (the Great Ice Age) is coined from the Greek and means simply "most recent." There is no reason why the general reader should attempt to memorize this patchwork. The four eras are important; and so, too, for general reading, is the fact that geologists often use Primary, Secondary, Tertiary, and Quarternary, to name these same eras in a most confusing manner. These numerical titles date back to a time before the prehistoric or Archean era was recognized. Thus Primary is Paleozoic, Secondary is Mesozoic, and (here is the greatest confusion) Tertiary and Quarternary divide Cainozoic time between them. Quarternary begins with the Great Ice Age (the Pleistocene period) and covers the years since, usually known as the Recent period, it is convenient to remember.*

Archean Era. As the curtain lifts, there were lands and oceans, sunshine and tides, much as to-day. But—and here is the almost unthinkable difference—there was no living thing to be seen, neither grass nor tree growing on the rocky hills nor fish in the sea, nor life stirring anywhere. A bleak, gloomy world of rock, lashed by the rain and torn by torrents, as wild and desolate as the Labrador coast to-day. There were probably more volcanoes than to-day, more earth-

THE MOON'S SURFACE FROM A PHOTOGRAPH MADE AT THE MOUNT WILSON OBSERVATORY.

The lifeless primordial earth was not unlike the surface of the moon in appearance.

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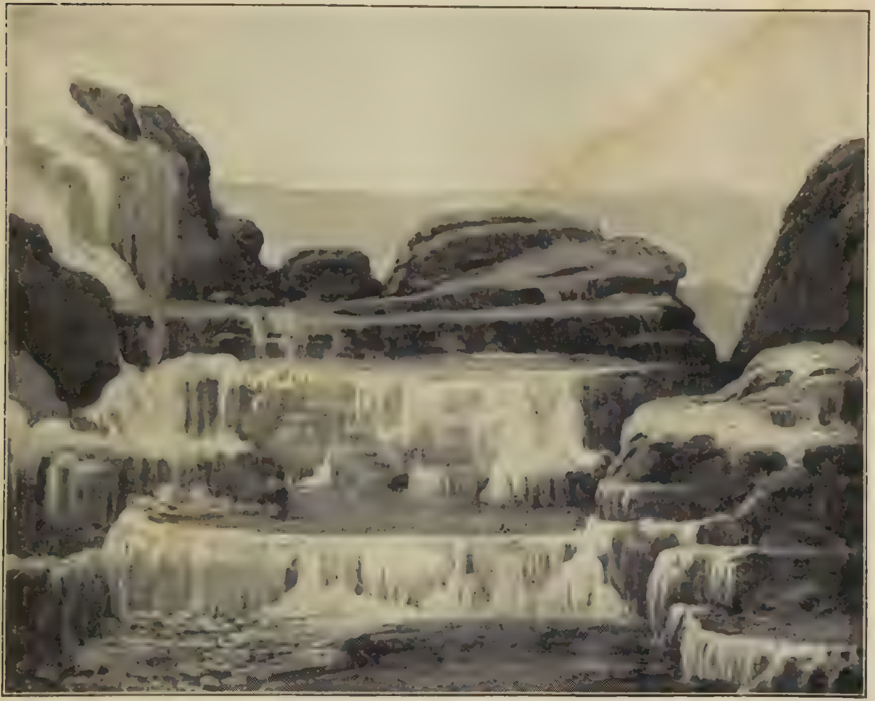
*It is an amusing commentary on geologic language that the word Pleistocene, meaning nothing more or less than "most recent," should now find itself placed just before the "Recent period."

quakes, more upwellings of molten rock. In these first barren years the world was shaken and torn as never thereafter—a world so different as to be almost unrecognizable. It has been compared to the moon in appearance. Yet already there was one vital difference. The surface of the moon is dead and unchanging; it presented to the earth then the same face that it presents to-day. For it is too small to hold an atmosphere. Whereas upon the earth, from the first, the vapor which arose from the sea remained aloft in clouds until it fell again as rain—and the great labor of levelling the high places of the earth began its appointed round.

For the first half of this era, however, weathering was not the prevailing force. Molten rock reached the surface so fast that it dominated the scene. To this period belong the great shields of Archean granite—like Labrador—not, probably, part of the first surface of the earth but pressed up under it in this early period. In the second half of the era began the great series of sedimentary rocks which continued down to the present time. There are three known series of this era. Thus at least three times the surface of the earth was piled high aloft and each time slowly worn away through millions of years.

Somewhere in this great stretch of time covering half the life of the earth, living things appeared for the first time upon the earth. The almost total absence of fossils for this era makes the history of its living things largely a matter of surmise. But they must have existed, in the water at any rate, and by the end of the era there must have been stirring most of the jellylike, backboneless animals.

An era of 250 million years that culminated in the production of worms may not seem like a great triumph. But right here, none the less, was the most extraordinary and inexplicable event of the whole story.

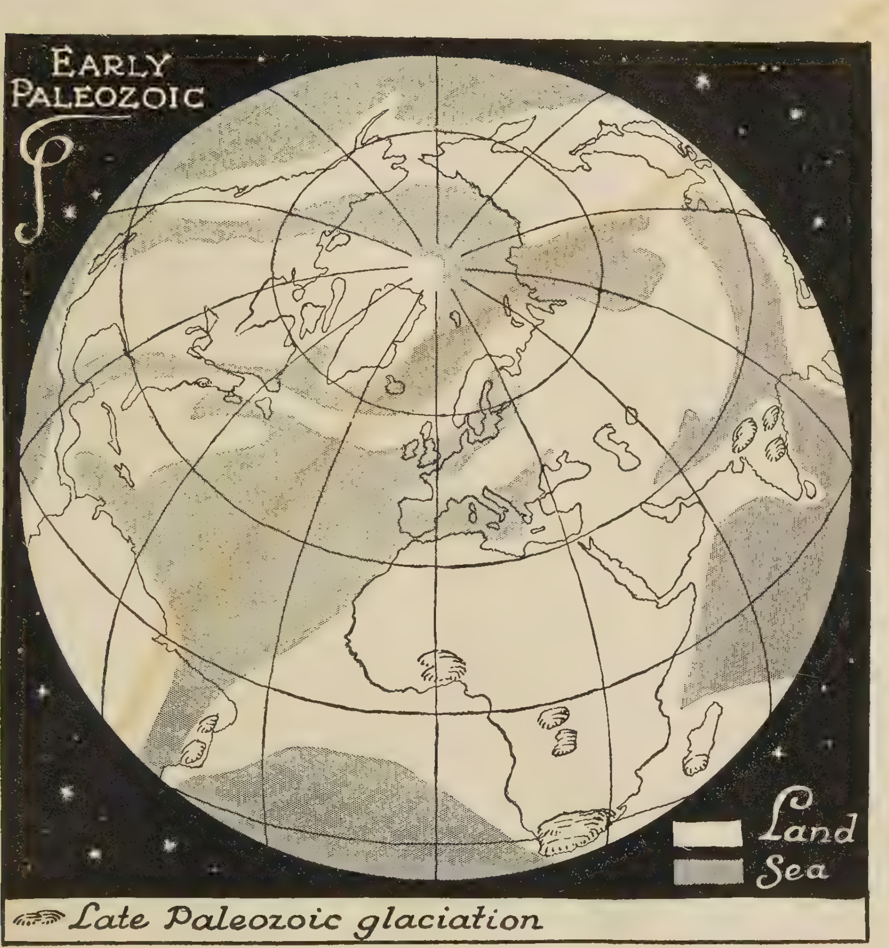


© *Field Museum of Natural History.*

THE BEGINNINGS OF LIFE.
Life may have originated in pools such as these.
From a painting by Charles R. Knight.

Paleozoic Era. There lay between these two eras one of the great mountain-making movements of the earth—"critical periods" these have been called, for at such times existing plants and animals are hard put to it to survive. The lands are high and the climate severe. The crumpling of the earth's surface produces long lines of weakness, through which the molten rock breaks in huge lava floods. (Volcanoes are a surface symptom of underlying stresses and disturbances—like the rash that accompanies a disease.) It is an hour of change and terrific test, for all its infinitely slow and majestic progress. Some geologists call this particular upheaval the Grand Canyon Revolution, for it was at this time that the Archean rocks at the bottom of the canyon were folded high aloft, perhaps as high as the present Alps. As we have seen, these great mountains were later worn away to sea-level, and it was with this long, peaceful age of erosion that this era opened.

This great upheaval is thought to have elevated most of North America above the sea for the first time. In general this whole era was one of relative quiet. Yet the disturbances of the earth's crust were sufficient to flood the interior of the continent again and again with a shallow inland sea. Along the eastern and western coasts, largely beyond the present shore-lines, were uprising areas which held their own. Each cycle of erosion slowly raised the level of the seas and slowly spread their waters over the low plains of the United States. Then as each uprise of the crust arrived the waters receded far more quickly than they came. In this quiet, rhythmical advance and retreat of the sea over the heart of North America, lasting not less than 150 million years, great events were occurring. The mollusk got his shell, and, more important, the fish got his back-bone, thereby placing himself in the great succession of animal advance. Fossils thus became abundant for the first time. And of prime importance to man of to-day, toward the end of the era fernlike trees developed in the swamp-lands which under the pressure of later rocks were to become coal.


EARLY PALEOZOIC
Land
Sea
Late Paleozoic glaciation

The era closed, as it began, in a terrific upheaval—the Appalachian. During all of Paleozoic time a separate continent had stood along the Atlantic coast, including that line and extending east and many miles beyond it. Where now are the Appalachian Mountains was a long trough of the sea, lying off the western coast of this ancient continent. This trough had generally subsided, and in consequence had been generally under water. It had therefore received a long deposit of sediments from the continent to the east—thirty or forty thousand feet in depth. We are to think of this long narrow trough of deposits as an area of weakness by comparison with the harder rocks on either side; and when the next "critical" hour arrived and the shell of the earth crumpled, it was precisely this trough of sedimentary rock which yielded and was folded violently aloft along its axis. What had been a sea-bottom for 30 million years was slowly pushed skyward into a towering chain of mountains extending from Pennsylvania to Alabama, perhaps as high as the Alps of to-day. Our Appalachian Mountains of to-day stand on the site of these Paleozoic ranges, but these ancient masses were worn completely away in the course of time. What we see now are lesser mountains uplifted in Cainozoic time, as a minor part of the next great upheaval, when the Rocky Mountains and the Andes were folded aloft from Alaska to Cape Horn.

The same great adjustment of the earth's shell folded great mountains aloft over Europe and Asia. Ireland, Wales, and

IN THE HIGH SIERRAS, YOSEMITE NATIONAL PARK.

northern and central France (then parts of one great continent) still show the stumps of these ancient ranges. The folding ran across central Germany and onward clear to the Pacific. The Ural Mountains were begun; and to the southeast the upheaval crossed to Australia, then connected to India.

In these last thousands of years that closed the Paleozoic era came also the first great glaciation. This was millions of years before the recent Great Ice Age, the manifold effects of which are still with us. This earlier Ice Age is, if anything, more difficult to explain than the later; for its traces are localized in India, Australia, and South Africa, far distant from either pole.*

Mesozoic Era. There followed a period one-third as long as the preceding and far more violent. It began, as has been noted, with the great Appalachian uplift. It ended, after 15 million years or more, with a great uplift along the Pacific which folded aloft the Rocky Mountains. In between came lesser disturbances that raised a long series of mountains east of the Appalachian, of which the Palisades on the Hudson (a flat sheet of molten lava) are a relic, and began the upraising of the Sierra Nevadas and the coast range of California and the Cascade Mountains to the north. The scene of activity shifted from east to west. The eastern coast remained continuously above sea-level, and the record of sediments for the era is small; they probably lie at the bottom of the Atlantic, a typical lost chapter of geology. In western North America the record is long. California, which had been under water, was raised above the sea, and the continent began to take on something of its present shape. The waters of the Pacific were cut off from the continent for all time. But toward the end of the era there came a great sinking of the western interior of North America, and a long, narrow inland sea spread from the Gulf of Mexico to the Arctic Ocean, sometimes called the Coloradoan Sea. In width, it extended from Dubuque to Salt Lake City, its western edge

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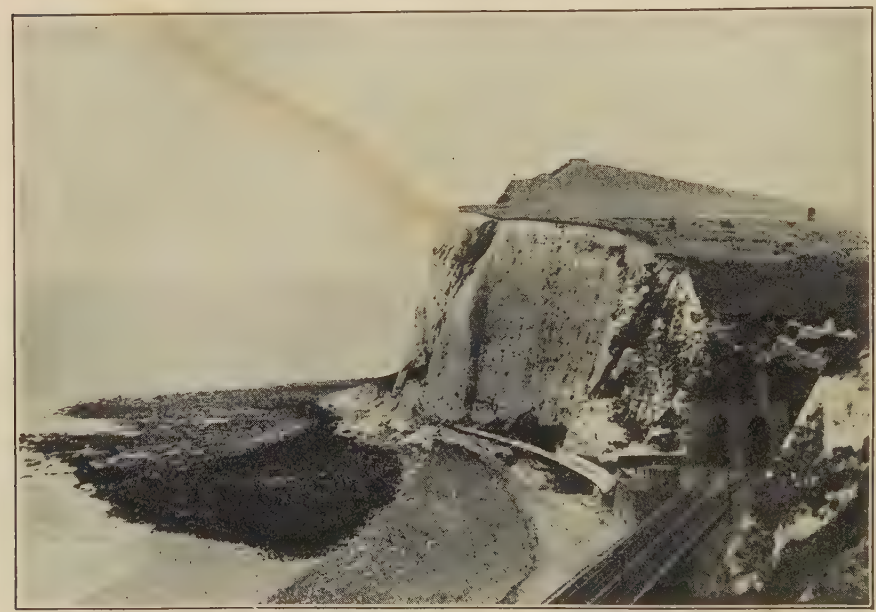
*The proof of this glacial period is now considered conclusive by most geologists. There is strong evidence of yet earlier glaciations, at the beginning of Paleozoic time and in the Archean era.



From a photograph by Ewing Galloway.

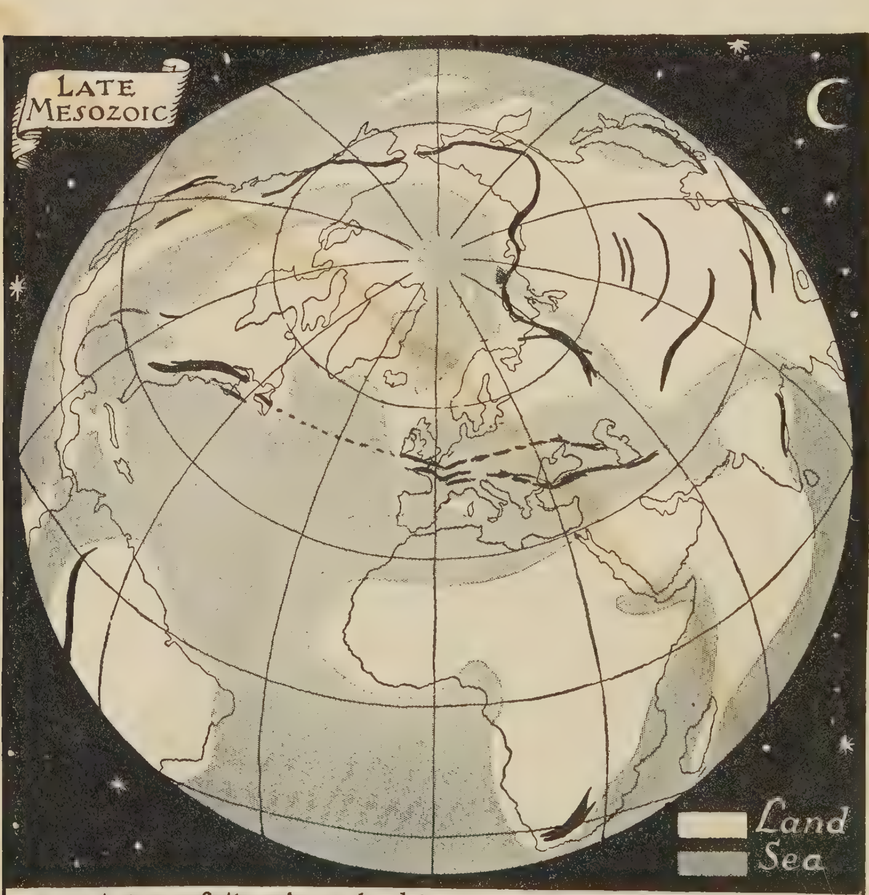
THE CHALK CLIFFS OF DOVER, ENGLAND.

reaching the site of the Rocky Mountains. All over the world the same conditions prevailed. A wide sea, spotted with islands, stretched across southern Europe and northern Africa to the Indian Ocean to the southeast and far north into Siberia—the giant ancestor of the present Mediterranean. In Europe the area of this greatest invasion by the sea is identified by the white chalk then deposited. Hence the name of the period, Cretaceous, which means chalky. Chalk, like some limestone, is formed of the shells of tiny mollusks. The chalk cliffs which line both sides of the British Channel for many miles are nothing but colossal beds of shells, laid down under water at this time when the sea covered the southern half of England and all of France.

There followed at the end of this era the great upheaval already mentioned as creating the Rocky Mountains. It was one of the greatest periods of mountain-making the world has seen. Mountain chains were folded aloft, roughly parallel to the Pacific coast, from Alaska to Southern Mexico and from Panama to Cape Horn.

Mesozoic was the age of reptiles which rose to gigantic size and then suddenly disappeared from the face of the earth. For ages they dominated land and sea and sky. But already, by the end of this era, the future of modern life was assured, for the first bird had appeared and a few small inconspicuous mammals, no larger than kittens, developed and managed to persist, pigmies in an age of giants, the future ancestors alike of tigers, elephants, and man.

Cainozoic Era. The first portions of this era are commonly called the Tertiary by the geologists. In this Tertiary period the continent of North America completed its modern outline. Florida appeared as an island and became a peninsula. The delta of the Mississippi began at Cairo, Illinois, and worked southward with the advancing coast-line. No great invasion by the sea occurred.



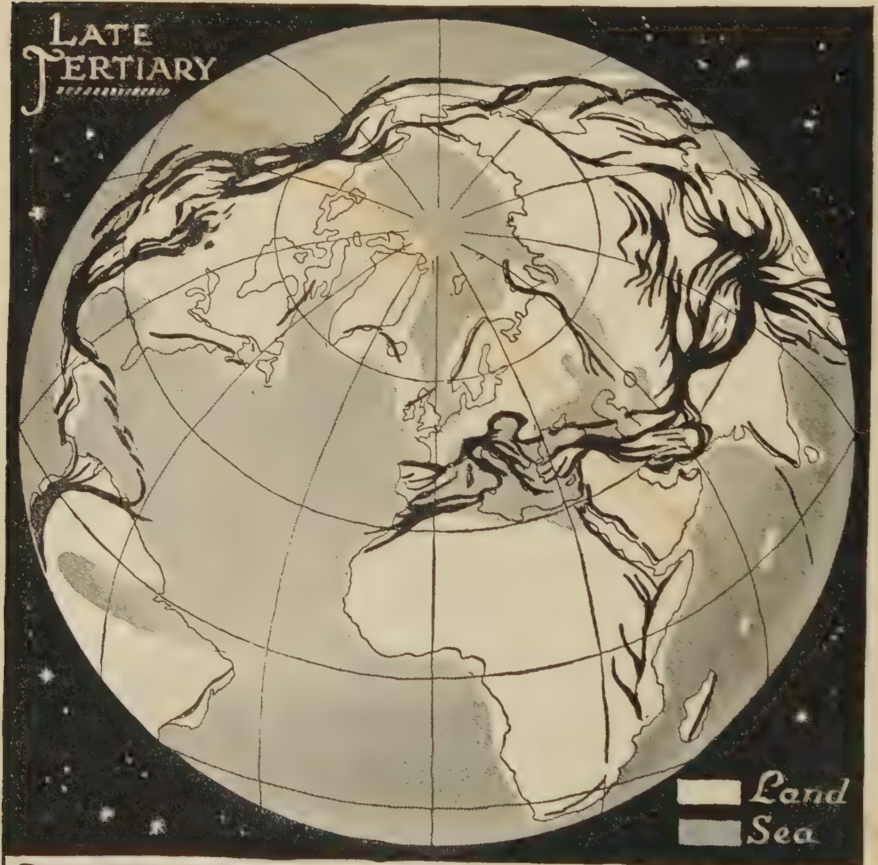
Mountains of the Appalachian period are shown in black

In Europe more remained to be done. The greater Mediterranean persisted for a long while, and united with the Arctic Ocean east of the Ural Mountains. Then about the middle of this Tertiary period there began the great Eurasian uplift. From Spain to China, from the Atlantic to the Pacific, there began slowly to fold aloft the colossal ranges of mountains of which the Alps and the Himalayas are the summits. It is interesting to note that this great Eurasian folding ran east and west, in sharp contrast with the great foldings of the western hemisphere, all of which ran north and south. The eastern half of the sea disappeared, and by the end of the Tertiary period the Mediterranean had appeared in its present form. The Caspian Sea was left as a relic of the ancient ocean.

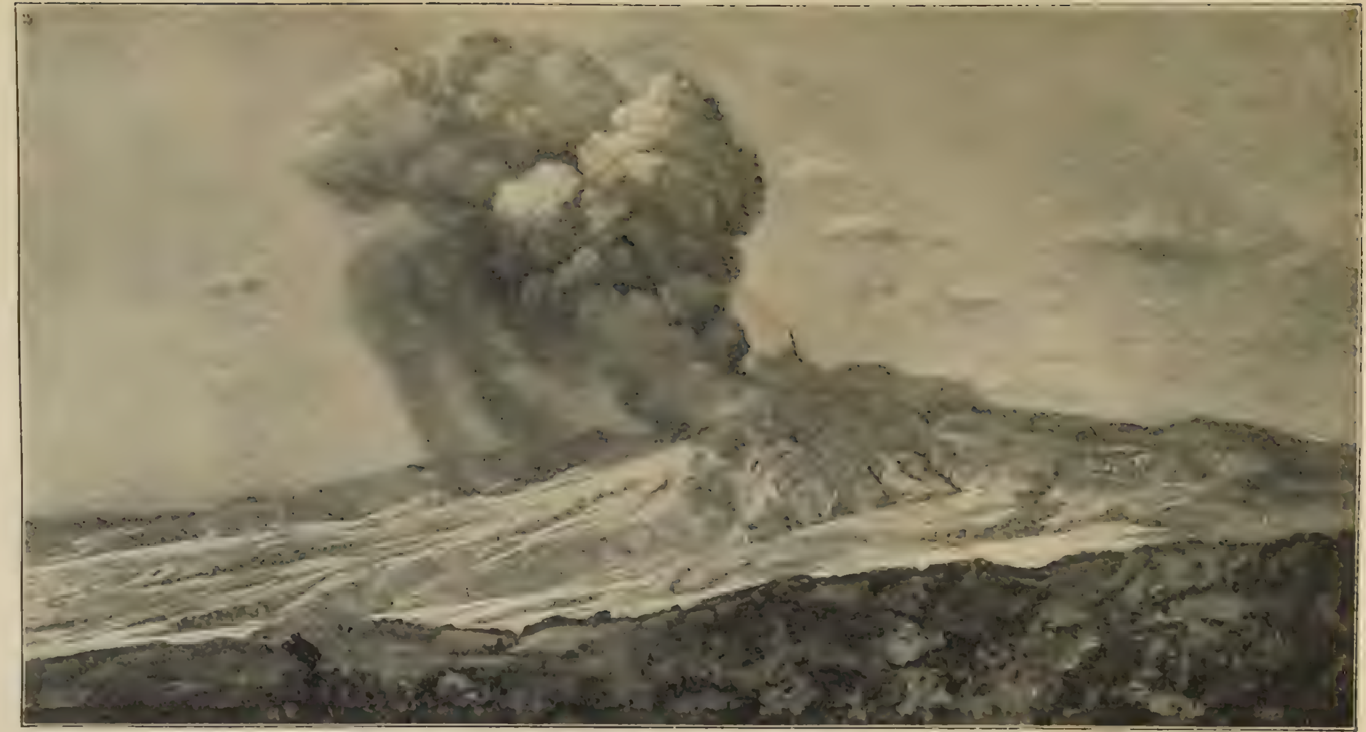
While the Alps and the Himalayas were being elevated in Eurasia, the entire western area of North America was again violently disturbed. There were active volcanic regions from Alaska to Mexico. The entire area of the Rocky Mountains, which had been much reduced in height by weathering, was pushed aloft again several thousand feet. As a result of this elevation the Colorado River began to cut its gorge—which makes the Grand Canyon a very young production, geologically speaking. Similar upheaving took place in South America and along the coast of China. Volcanoes now fronted the Pacific Ocean, east and west, "a ring of fire." The earth as man now sees it, barring only a few hundred thousand years of wear and tear, stepped forth to view at the end of this

Tertiary period. It is in the magnificent handiwork of this last great "critical" period that man now lives.

Some geologists, indeed, consider that the period itself actually persists to-day, that the adjustments of a "critical" period are still taking place. Perhaps they are right. One cannot be sure. It is easy to see the results of such a period, but its processes are too gradual to be measured while in action.



Tertiary mountains are shown in black



Courtesy American Museum of Natural History.

THE ERUPTION OF MT. PELÉE.

During the volcanic activity of the middle Tertiary the entire Pacific coast looked like this.

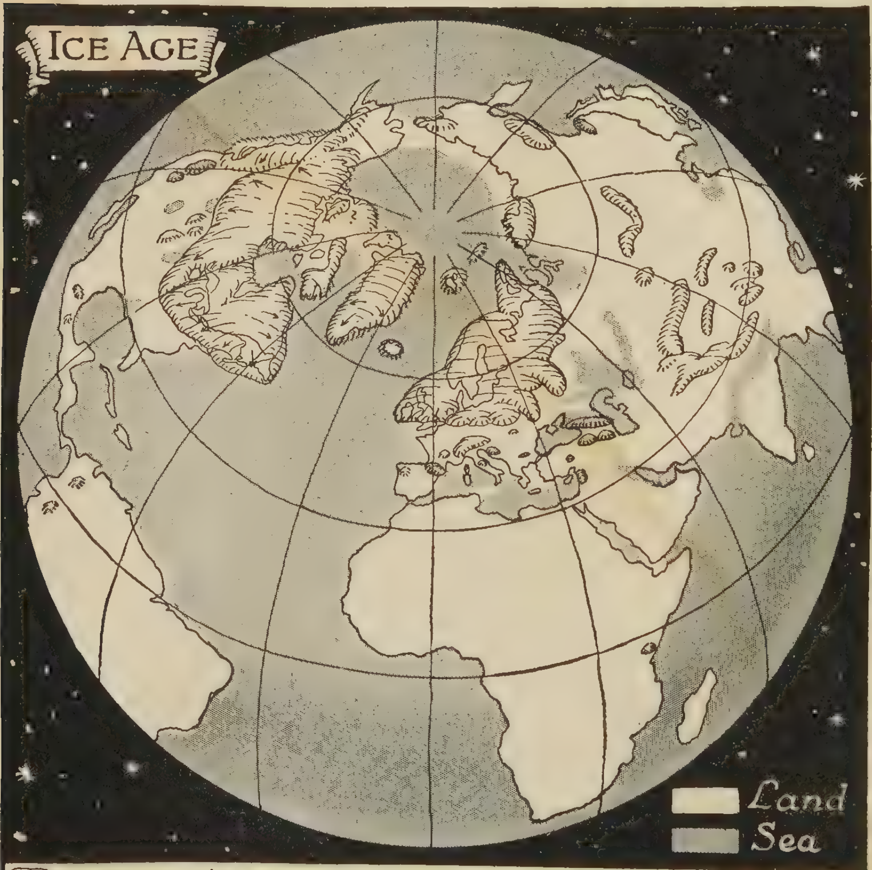
From a painting by Charles R. Knight.

True or false, the view is valuable as giving a notion of the infinite slowness with which the most magnificent revolutions of the earth's surface come invisibly to pass. The "upheavals" and "crises" of which geologists speak spread over tens of thousands of years.

The Tertiary was the age of mammals which developed from the small primitive forms that led a precarious life among the great reptiles to an extraordinary array of powerful and intelligent animals—horses, camels, elephants, mastodons, sabre-toothed tigers, etc.

With the Quaternary began that most mysterious of all eras, the Great Ice Age. Earlier periods of glaciation have been noted. Now, again, for reasons as yet unfathomed, the usually mild climate of the earth turned to cold, and for thousands of years great ice-sheets blotted out two considerable areas of the globe. These sheets have to-day retreated but they have not disappeared. Greenland still lies under a gigantic sheet of ice perhaps 8,000 feet thick. So does all Antarctica, the continent lying about the South Pole. The local glaciers scattered throughout the world—even near the equator—at great elevations, flowing down from the high mountains like frozen rivers, give but a scant idea of these vast ice-sheets, their intense cold, their colossal power, their terrible beauty.

One may think of this white terror inching down from the north through the Pleistocene centuries till all Canada was covered, and the edge touched Oregon, Idaho, Montana, and turning southward midway across the Dakotas reached the northeastern corner of Kansas. All the States which now



Glaciation at its biggest extent.

border on the Great Lakes lay under the shield, and all the northeastern States as far south as New York City.

There were three of these great ice-sheets in America, varying from a hundred feet thick to a mile or more. All slid slowly seaward as a rule—wherever the slope of the earth and their tremendous weight drove them. They scoured out ponds, deepened valleys, deposited great beds of clay and heaps of boulders which they had carried down with them.

The other great ice-sheets were in northwestern Europe. They covered the British Isles (excepting the southern coast), Holland, Germany, and a great sweep of country about the Baltic. The eternal snow of the Alps descended from an altitude of 8,500 feet to an altitude of 5,500 feet, spreading over a wide area. Everywhere in the northern hemisphere was a colder climate than any known to have existed before. The reindeer ranged over the Pyrenees; the walrus was at home on the shores of Virginia.

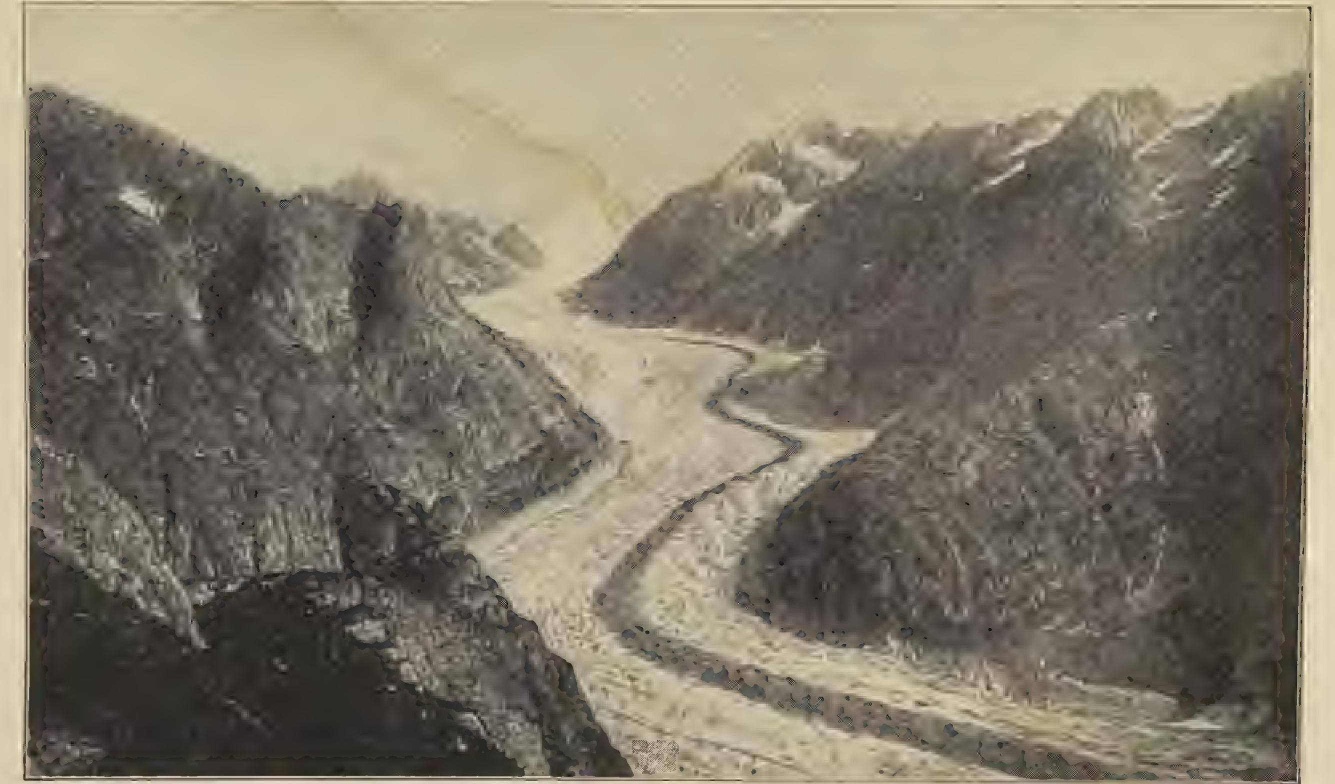
There is unmistakable evidence that the ice advanced, retreated, and advanced again. Some geologists believe they have evidence that six such advances occurred with milder climates lying between. Most scientists consider that there were two or three. But the question is much vexed, and the exact number must be left open.

There is also evidence that the climate of the whole world was affected, became generally cooler. Yet the intense glaciation was restricted to the areas of Europe and North America described. Elsewhere glaciation was found only at high altitudes, as to-day. This peculiar localization of the Great Ice Age, around the North Atlantic, roughly speaking, presents one of its most puzzling features. It has been sought to explain this condition on the theory of polar wandering; that is to say, that the axis of the earth has shifted, and that in this glaciation the North Pole was somewhere in Greenland. In the earlier glaciation, according to this view, the North Pole was in Mexico and the South Pole in the Indian Ocean. But this theory has won little support. More faith is now placed in the effects of changes in the earth's surface which change air-currents and ocean currents. Undoubtedly, too, the sun's energy is variable, and glaciation may have resulted from a prolonged lessening of its heat. Many other theories have been put forward. None is without objections, and the whole problem is still open. As was stated before, scientists do not know why glaciation occurred, and are utterly unable to predict whether it will occur again, or late or soon.

In one of these warmer spells, as the ice-sheets withdrew from Europe, a strange animal appeared upon the earth, somewhat resembling the great apes but widely different. He was man, and destined henceforward to hold the centre of the scene.

Lost Continents and Land Bridges. The shape of the early continents and oceans, their connections and their fate, have been constant sources of speculation by geologists. It cannot be said that many secure conclusions have been reached.

A "lost continent" which has gained considerable acceptance has been named Gondwana Land, after a district in India. It is conceived of as a great east and west continent south of the equator, connecting northern South America with Africa and extending across the Indian Ocean to India



THE VIESCH GLACIER, SWITZERLAND.

A glacier may be compared to a river of stiff liquid, the dark band of rock debris marking the central current

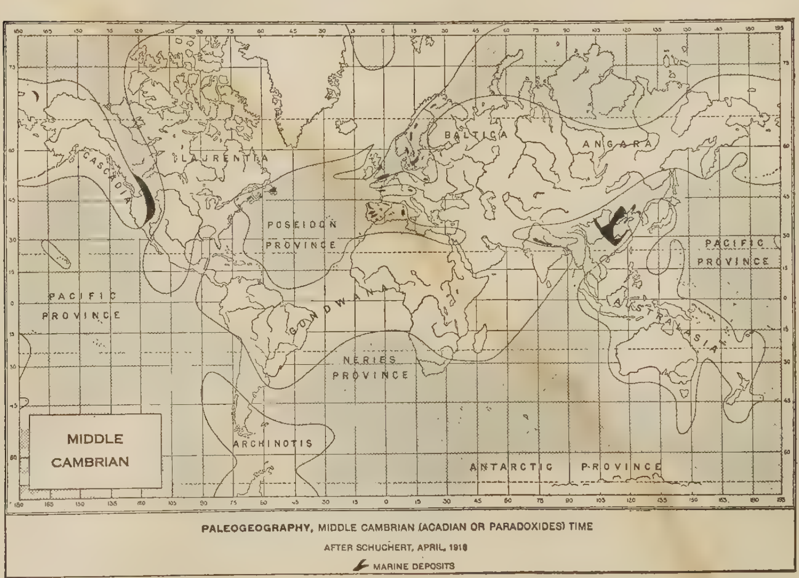
and Australia. It is held to have been in existence during most of the Paleozoic era. If so, the Atlantic portion, connecting South America with Africa, sank beneath the ocean in late Mesozoic time. The connections between Africa and India and between India and Australia disappeared later, in the Cainozoic era.

It is the fossils which have led to the belief in this ancient continent. There is in particular a flora of which a certain fern is typical, that occurs in the strata of Paleozoic time only in Brazil, Africa, India, and Southern Russia and Australia. It is difficult to account for this peculiar distribution of these plants except on the theory that these continents were at this time united.

As an alternative theory other geologists have suggested that there was a land connection between Australia and New Zealand and Antarctica, and that South America and Africa were connected with the same continent. This is a less daring hypothesis and probably has more support. It would account for the same distribution of flora as would Gondwana Land, it will be noticed.

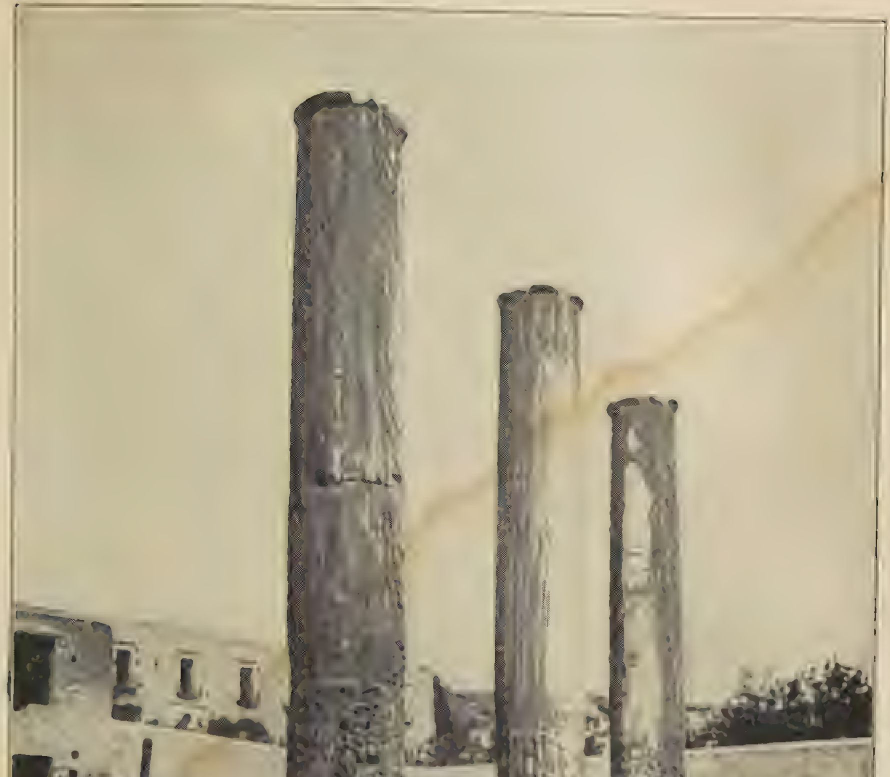
There is much more general agreement among geologists in favor of the view that the continents in the northern hemisphere were connected at this time, almost the world around. The fossil evidence of such connections is very strong. Thus the mammals of Europe and North America are held to have intermigrated via Greenland until not long before the Great Ice Age of the Pleistocene period. Then the connection between Greenland and Great Britain and Scandinavia was broken, and also the connection between Greenland and Canada.

Perhaps at about the same period, North and South America, which had been separated during Paleozoic time, were united by the uprisings of Central America. As for the much-debated land bridge between Alaska and Siberia—where now is Bering Strait—it is thought to have existed until possibly flooded by the sea at this same time, when the connections of America with Greenland were broken. But if so, the flooding was shallow (as to-day), and the bridge was probably re-


CASCADIA
LAURENTIA
BALTICA
ANGARA
POSEIDON PROVINCE
PACIFIC PROVINCE
PACIFIC PROVINCE
GONDWANA
AUSTRALASIA
NERIES PROVINCE
ARCHINOTIS
ANTARCTIC PROVINCE
MIDDLE CAMBRIAN
PALEOGEOGRAPHY, MIDDLE CAMBRIAN (ACADIAN OR PARADOXIDES) TIME
AFTER SCHUCHERT, APRIL, 1918
MARINE DEPOSITS

Courtesy American Museum of Natural History.

THEORETIC MAP OF THE WORLD IN EARLY PALEOZOIC TIME, SHOWING THE CONTINENT OF "GONDWANA" CONNECTING AFRICA AND SOUTH AMERICA.



From a photograph by Ewing Galloway.

THE TEMPLE OF JUPITER SERAPIS NEAR NAPLES.

The borings made by sea animals while the temple was submerged show plainly in the picture.

established through much of Cainozoic time. The camel, or rather his ancestor, originated in North America during early Mesozoic time, spread southward across the new land bridge to South America and northward across the land bridge to Asia. Large camels were still numerous in North America in the Great Ice Age.

England was attached to France until fairly recent times, well into the period of glaciation. The first men probably walked across a valley where now lie the Straits of Dover.

Similar land bridges may have connected until the same recent period Spain with Africa, Italy with Africa (via Sicily and Malta), and Turkey with Asia Minor. If the Straits of Gibraltar were in fact thus lately closed, the sea within was lower than the ocean without, and there may well have been a terrific flood when the Atlantic first poured through the narrow gates. But this view rests on a slender basis. It is not to be classed with the solid facts of geology.

Of these facts, nothing is clearer than that the same forces which have been traced through millions of years are still active. A tower erected at the mouth of the River Rhône in 1737 is now nearly four miles inland. At the mouth of the Po, the city of Ravenna, which was once an island city like Venice, has now a wide stretch of downs and a pine forest between it and the sea. The Mississippi adds a mile to its delta every sixteen years. For the reverse, the sea wears away the Yorkshire coast of England seven feet a year; since the Norman Conquest a strip a mile wide, with farms and towns, has been lost. In addition, there are warpings of the coast, wide movements up and down, which can be observed in action. The site of the old town of Louisburg, on Cape Breton Island, Nova Scotia, has sunk beneath the sea. Near Naples there are the ruins of an old Roman temple which show plainly that they at some time sank beneath the sea and were exposed to the action of sea-animals for a long period. They were later raised again above sea-level, where they now stand.

"Terra firma" is anything but the solid base that the words imply. It is slowly, invisibly stirring the world around—as it has stirred since the earth came into being. The crust is still wrinkling and warping as it adjusts itself to the shifting masses; and the ridges, great and small, thus folded aloft, are still unceasingly swept toward the sea by the rain and weather. The cycle of change shows no pause, and science sees no hint of an end in sight.

CHAPTER IV

THE MYSTERY OF LIFE

It was the teaching of Aristotle that worms, insects, even fishes, could originate in mud—not be born of other worms or insects or fishes lying in mud, but be born directly from the mud. Spontaneous generation the process was called, and it was believed in down to the seventeenth century A. D. A typical mediæval writer, Swan, remarks that a dead horse breeds wasps, a mule hornets, while from an ass arise bumblebees. All this seems absurd in the light of modern science; yet there is still misunderstanding of this peculiar quality of life. Worms cannot be born except from other worms, just as human beings cannot be born except from human beings, we know. What of germs, what of all the small organisms, visible only under the microscope, that cause milk to sour, apples to rot, cheese to mould, people to fall sick? Do they not appear from nowhere, are they not self-starting, so to speak? It was the great achievement of Pasteur, the French chemist and biologist of the last century, to prove that no life originates in this way. If germs are completely excluded from a sealed jar, none will appear therein. When apples are boiled and canned (thus, if the canning is expertly done, killing all germs in the apple and keeping out the germs that are present in the air), no worm ever grows, because any worm eggs that may have been in the apple have been killed, and, equally, no rot or mould appears, for any microscopic germs which might give birth to their swarms of descendants have been killed. Asepsis in modern surgery, by which wounds are kept from infection, rests upon the same principle, though obviously more difficult to apply, for one cannot shut up a human being in an air-tight jar.

Life is so profuse and cheap about us that it is hard to realize that it is not originating afresh a thousand times a day. But so far as scientists can ascertain, it is not. New living things are being born in enormous numbers every second of time. They are born only of other living things. If one wishes to stock a pond with fish, one must get the living spawn of other fish. To grow a field of corn, one must plant the living seed of other corn. There is a chain of life in every species, animal and vegetable, a chain that runs back generation by generation, from existing animals and plants all the way to the mists of Archean time. It is only because that chain is unbroken that there is life on the earth to-day. Stated in another fashion, all living things, including man, are part of one family tree, the branches and trunk of which are to be sought through all geologic time. It is the roots of that trunk, the beginning of life upon the earth, that must be considered.

The difficulties of the problem are obvious. Life originated upon the earth millions of years ago. At one period there was a lifeless world, displaying heat and cold and substances forming and reforming—the physical and chemical processes, in short, exactly as they occur now. But there is not one cell of living matter. The next period there appears this strange thing, so primitive in character that it is impossible to say whether it is animal or vegetable, a mere piece of jelly, perhaps, floating in the sea, but possessing new and extraordinary qualities. It has the power to absorb material (to feed itself), to grow and to reproduce (to split into smaller pieces of jelly when it becomes too large, the most primitive form of birth). There is no satisfactory definition of life, but such qualities as these are of its essence.

Courtesy American Museum of Natural History.

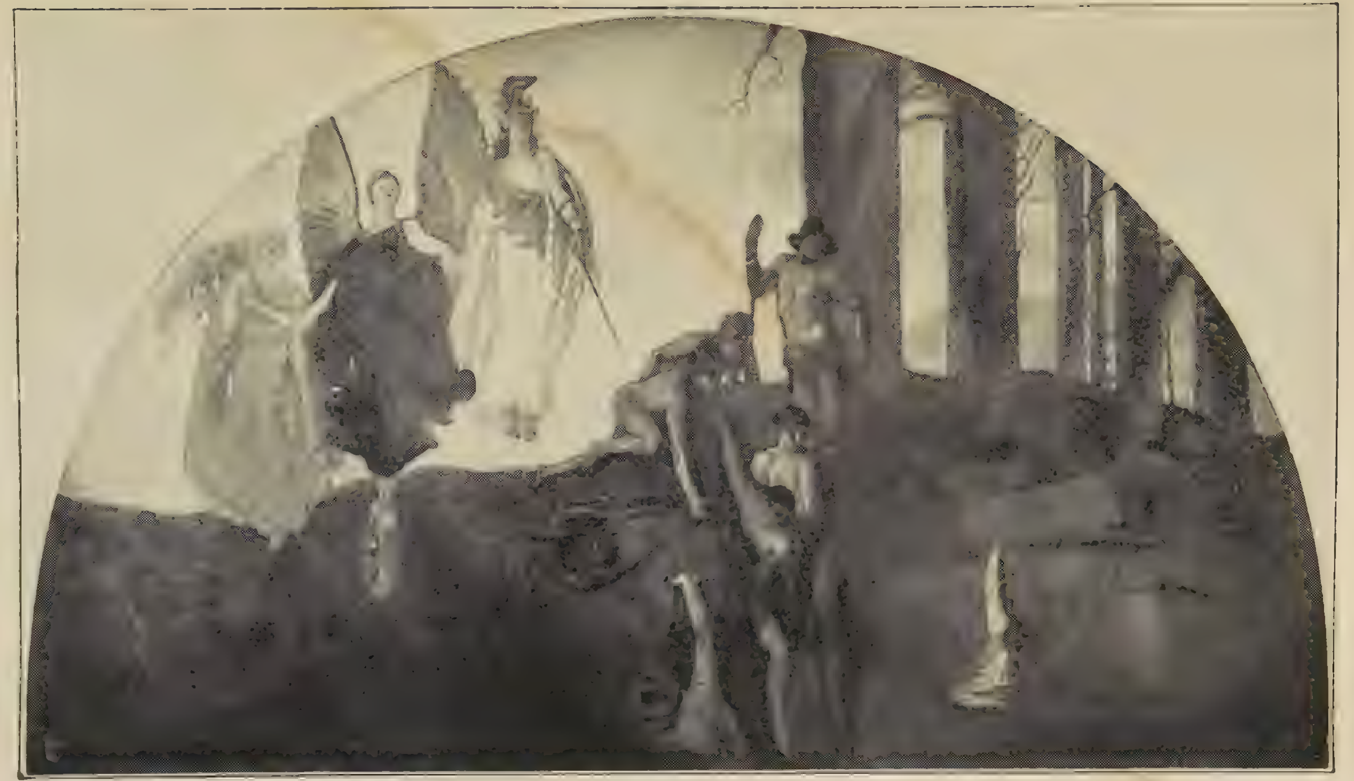
A LIVING ALGAL POOL COLONY IN YELLOWSTONE PARK.

One can only guess the period at which this stupendous event occurred. One cannot surmise how long the production of such a floating jelly (if life did begin in the sea) lasted. But at some point the direct production of living matter from non-living matter apparently ceased. The future of life rested with the mass of living, reproducing matter by this time brought into existence. There is thus a most extraordinary development of a new substance possessing amazing qualities, and this creation limited to a brief period in the earth's history.

No wonder there has always been and is to-day a school of thinkers, called vitalists, who see in this event no mere orderly development of physical events but an interposition by forces not yet touched by science, from a world of spirit, perhaps—or, in the phraseology of religion, the hand of God reaching down and directly adding this strange thing, life, to the physical world.

There is a later event in evolution which offers much the same problem. That is the development of consciousness. Nothing seems simpler to man than the fact that he sees and knows. Consciousness is as unmistakable as life. Yet it is just as difficult to analyze or to define or to comprehend. Here again is another step at which there is a colossal difficulty for science and a corresponding tendency to seek an explanation in the supernatural.

Science has not travelled far toward explaining this event in terms of its present outlook. Biology and organic chemistry



Edwin A. Abbey.

SCIENCE REVEALING THE TREASURES OF EARTH.

From a painting by Edwin A. Abbey in the Pennsylvania State Capitol.

have accomplished much in the analysis of living matter. The chemists have studied the peculiar substance of which all living things are composed—protoplasm, they call it, which means first substance. They know that it is grayish, sticky, semitransparent. They know what elements compose it, but they do not know how those elements are arranged in it. For that arrangement is exceedingly elaborate and complicated; and it breaks down and disappears as soon as the protoplasm is subjected to chemical analysis. In short, the arrangement is an essential part of life, and the chemist, unfortunately, cannot commence to separate protoplasm into its parts without killing it. The secret vanishes as he reaches for it.

The biologists have learned that this living stuff or protoplasm of which man is made is divided into tiny units, more or less round, covered with a thin wall, visible only under the microscope, called cells. There are millions of these cells in a man or in any of the higher animals. At the lower end of the scale are animals consisting of only one cell—the bacteria of disease, for example, or the famous amœba, the simplest animal known.

For all this progress in analyzing life, science has not succeeded in making protoplasm. The complex, delicate arrangement of common elements in a living substance, that nature accomplished millions of years ago and that all living things reproduce so profusely to-day, has never been imitated by man. Science has not made a single cell of living matter out of non-living matter. If all living things upon the earth except man were to die, scientists could not replace them with a single blade of grass. Man would perish, too, because he would starve to death without flesh or vegetables to eat.

SVANTE ARRHENIUS.

The mystery of how life appeared upon the earth is thus still unsolved by science. So difficult has the problem seemed at times that great scientists, Lord Kelvin, of England, and Svante Arrhenius, of Sweden, have put forward the extraordinary suggestion that the germs of life came to the earth through the interstellar spaces from other planets or suns. This seems incredible, and the scientific difficulties involved in it are many; it is, however, a possibility. But, in any event, it does not explain the origin of life; it merely pushes that occurrence far away to a distant spot.

In face of this unsolved problem, what is the attitude of scientists? What should be our attitude? Some scientists hold to the vitalistic theory, described above. But the majority of scientists do not consider that the time has yet arisen for turning to such an explanation. Here, they argue, is but another difficulty for science to study and solve. It happens to be a particularly baffling one. But as yet there is no clear evidence that there are any facts involved which will not some day be explained by physical and chemical laws. All modern science has progressed, they argue, on the theory that the physical universe is one, that a chain of cause and effect binds together all things that happen from the lowest to the highest. It is too early to reject this theory in this single case of life and assume an impassable gulf between living and nonliving things.

The second of these two theories is often called the mechanistic theory of life—because it seeks to explain a living thing exactly as it explains a steam-engine, let us say. But it by no means contradicts the idea of a God working through the laws of evolution. As to this religious interpretation of life, science here, as throughout, neither affirms nor denies.

The appearance of life upon the earth thus remains one of the unsolved riddles of the universe. It may always remain so. We can believe as we will with respect to it provided we take care to leave science wholly free to study it without prejudice.

CHAPTER V

FROM AMŒBA TO MAN

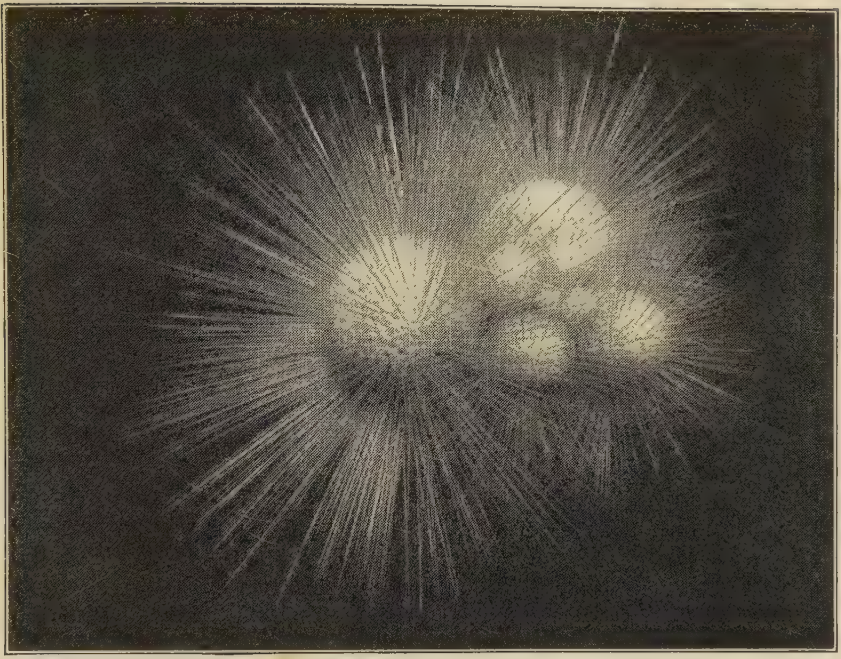
I. THE THEORY OF EVOLUTION

The amœba walks with his stomach, it is sometimes said. It would be equally true to say that he eats with his legs. More accurately, he has neither stomach nor legs, but only one cell of protoplasm with which to walk and eat and do all that he does. He has neither back-bone nor lungs nor jaws nor blood nor brains, nor anything else of the elaborate special equipment that goes to make up the complicated machinery of a man.

The story of evolution of life upon the earth tells how from these cells came man—of how a creature composed of one small speck of living matter, capable of doing only a few things clumsily, was the ancestor of creatures possessing millions of cells arranged in special organs, legs, stomachs, brains, what-not, all delicately adjusted to special tasks.

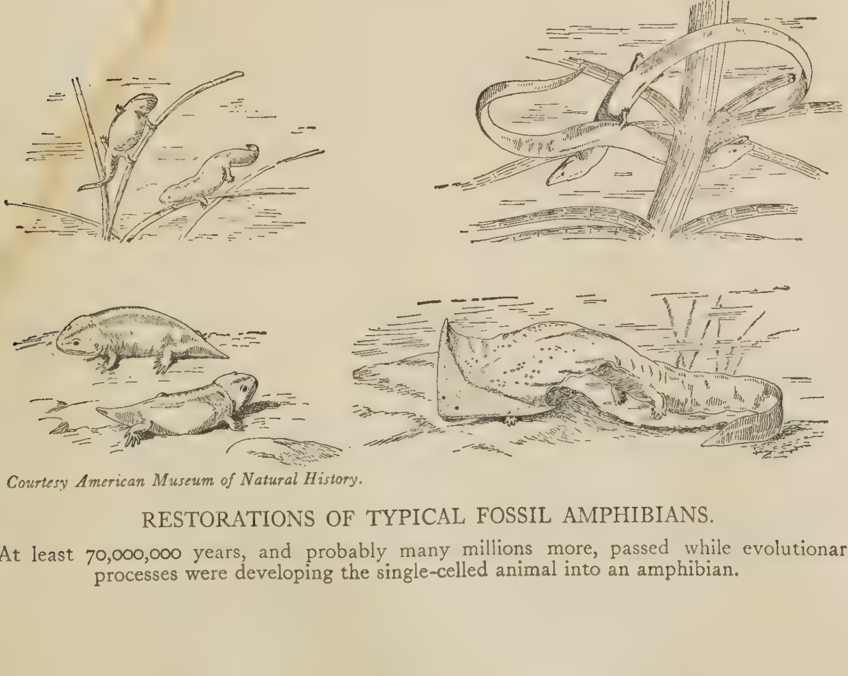
When one compares an amœba with a man, their relationship seems inconceivable. But if one begins at the beginning of fossil life and traces the slow development of parts and organs, one by one, from their simplest beginnings through this era of life and that, the idea becomes not only possible but inescapable. Development was far slower in the early stages than later. One can consider that the rate of progress has been constantly accelerating. It took half the life of the earth for animal life to develop hard bony parts, without which no highly efficient life is possible. A world peopled only by worms or jelly-fish, however enormous or wise, could never accomplish much. There were needed more millions of years before this bone-making ability formed that most precious of possessions, a back-bone. This great event occurred in the sea, where all the early development of animals took place, and it is from these ancient fishes that all vertebrate life is descended—that man got his back-bone, if you will. Legs and lungs came long after, as the first animals began to climb out on the dry land. Man has legs and toes because some fifty or more million years ago queer venturesome amphibians learned to pull themselves shamblingly along a beach. And so on clear down to that fateful hour when, only half a million years ago—or perhaps a million—some hairy creatures of the forest (neither man nor monkey, but their remote common ancestor), for some unknown reason, began to walk on their hind legs, thereby converting fore paws into hands, and making mankind possible.

This general theory of evolution is part of every-day thought now. A man speaks of the evolution of the automobile when he means its gradual development from feeble, clumsy carriages to swift and mighty cars. Generations are growing up in a world that takes evolution for granted as the basis of all thinking. It has become more than mere hy-



SKELETON OF THE FORAMINIFER, A TYPICAL SINGLE-CELLED ANIMAL THIRTY TIMES ACTUAL SIZE.

As the animal grows it forms new shells adjoining the earlier ones until a cluster such as this is made.



Courtesy American Museum of Natural History.

RESTORATIONS OF TYPICAL FOSSIL AMPHIBIANS.

At least 70,000,000 years, and probably many millions more, passed while evolutionary processes were developing the single-celled animal into an amphibian.

pothesis; it has been so thoroughly tested and confirmed that it has attained, in part at least (as it relates to living things), the status of scientific law, like the law of gravitation. Yet we should none the less understand the basis on which it rests and exactly what its terms are. For not even the oldest scientific law is exempt from modification and development; the law of gravitation itself is at present being re-examined in the light of the Einstein hypothesis of relativity, an immensely complicated theory of higher mathematics. Similarly, evolution is to be viewed as a general law of development that is certain to undergo great development itself. Such is the nature of all science. Its wisdom is not a body of permanent and unalterable laws built into the universe, so to speak. It is but a very human attempt to classify facts as man observes them, and to state his view of their relationship to one another in laws that are necessarily tentative and incomplete, and that inevitably grow, alter, and are transformed from decade to decade. It would probably be better if these working hypotheses were not called "laws" at all. But the usage is confirmed, and there need be no confusion if the character of these "laws" of science is understood.

The idea of evolution has long been in the world. It appeared first in Greece, flung off as a beautiful speculation. The great philosophers of many centuries gave it place in their systems. But it was none of these philosophers who established it on a secure basis. That was done by Charles Darwin, a naturalist, not a philosopher, a scientist, whose motto was "Dogged does it!" He was a born observer, as a boy fond of roving the fields and collecting beetles. He shipped on a voyage of exploration at the age of twenty-two as a naturalist, and for five years shared the adventures of the famous *Beagle*, which he has described in his delightful book "The Voyage of the Beagle." He was much struck by the way in which species vary from place to place and from time to time, among fossils and among living animals. The birds and

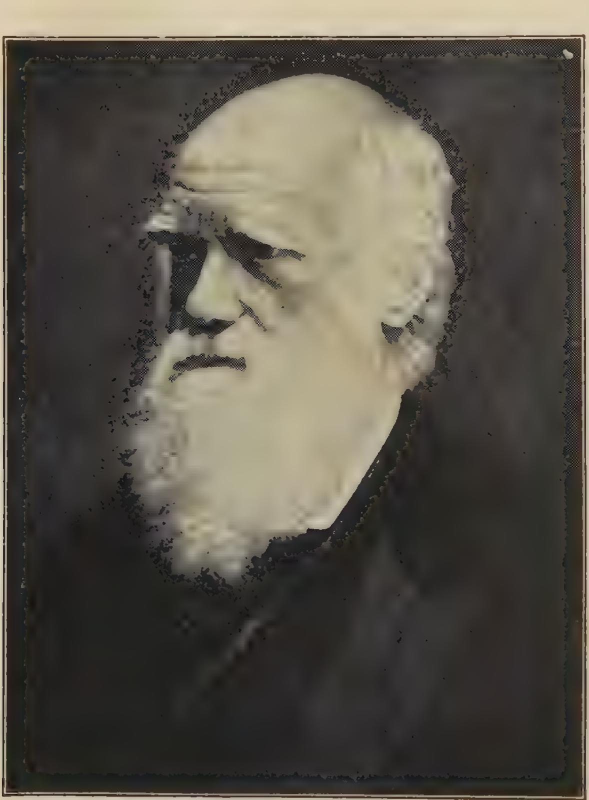
A. R. WALLACE.

tortoises on the Galapagos Islands especially puzzled him by their resemblances and their differences.

It was a study of the breeding of domestic animals that finally suggested an explanation of evolution in the theory of "natural selection." The race-horse is bred for speed and the cow for milk, by selecting the best specimens of each generation and breeding from them alone—an "artificial selection," in short. Darwin conceived that nature selected and bred in the same fashion. Only the principle of selection was not any ideal of speed or beauty or milk production, but simply fitness to environment. The desert bred the camel, the mountain the goat, the plains the buffalo, the deep sea the whale, the soil the mole, the skies the eagle.

It is a simple enough idea. But it was a tremendous discovery—one of the great ideas of all time. It came to Darwin suddenly in 1838. He at once saw its possibilities. But what did he do? Nothing could better illustrate the turn of his mind. Here with the solution, the long-sought explanation of evolution, within his grasp, he sat down and for twenty years worked in silence to verify it. When he finally published his theory in 1858, it was supported by this wealth of evidence based upon these years of painstaking study. As a matter of fact, another British naturalist, A. R. Wallace, hit upon the same idea in this same year. But Darwin deserved and has received the credit for the great discovery, for it was his lifetime of research that put the idea upon secure ground.

Evolution rests upon a broad basis of evidence, upon the cumulative effect of countless small facts all pointing in one direction. One of the chief sources of proof is paleontology, the science of fossils (literally, the science of ancient beings).



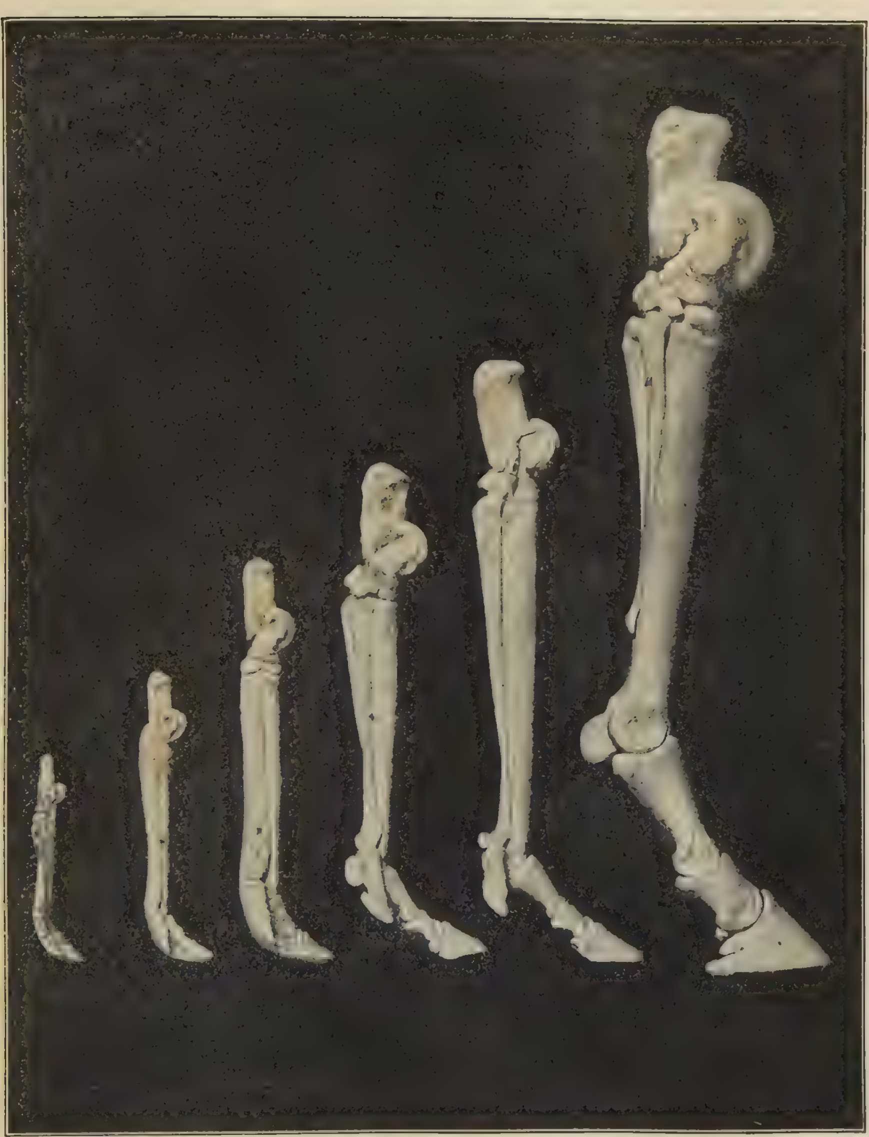
CHARLES DARWIN.

The most extraordinary confirmation is found in long series of mollusks and fish showing exactly the slow development from one million of years to another that the theory would demand. The lowest animals and plants are found in the oldest strata; each successive stratum shows a slow ascent. Fossil life is so incomplete that there can obviously be nothing like an unbroken chain of ancestry. By good luck there are certain links of the chain amazingly complete. But there are also huge gaps probably lost for all time. Far more has been lost to us than has come down. It is, therefore, not at all extraordinary that the remoter ancestry of man, for example, should be wholly missing. The earliest human skeletons found are those of a more primitive man than man of to-day. Beyond them, of those distant ancestors from whom alike man and the great apes are probably descended, little has as yet been found.

It is perhaps on its negative side that this fossil evidence is most impressive. The skeleton of one tiger found in the strata of the age of fishes would have overturned the entire theory of evolution, be it noted. For over half a century thousands upon thousands of fossils have been critically examined from this point of view. Not one has been found to violate the general theory of slowly developing life. There were no tigers until the higher mammals appeared; there were no reptiles until life in the sea had developed for millions of years; there are no "mistakes" or "exceptions" in this silent record of the dead.

The branches of the tree of life can also be traced from fossils to living forms. Take such a peculiar fact, for example, as that the highest mammals in Australia (outside those introduced by man) are all of the kangaroo type called marsupials. That is to say, their young, instead of being born fully formed, are born imperfect, and are carried by the mother in a pouch of flesh. The fossil mammals of Australia are all of the same low type, contrasting strongly with the fossils of other continents. Take the sloths, ant-eaters, and armadillos of South America, queer animals found on no other continent. Their unmistakable ancestors, the extinct Megatheriums and Glyptodons, are found only in the same region. The modern horse has been traced back through fossils several million years to a remote ancestor who ran about Europe on four toes. It is assumed there was a yet older ancestor with five toes, but no fossil of a horse with five toes has yet been found. He gradually developed an inside toe into a hoof (in adaptation to the needs of life on rough, hard ground as opposed to an earlier existence in marshy land) and lost the other toes. You can see the remnants of these lost toes in the thin, splint-like bones lying along the legs of any horse today. According to the time schedule of these fossils, it took the horse millions of years to lose each toe.

This example brings up the second great source of evidence. If the theory of evolution is correct, there should be many remnants of the past in the structure of animals today. There are. The anatomists have counted several hundred of them in the body of man—vestigial structures, they are called; which is to say that they are vestiges or traces of animal ancestry. Take the muscles by which some humans can move slightly their ears. Many animals—the horse, for instance—have these muscles well developed. They wiggle



Courtesy American Museum of Natural History.

EVOLUTION OF THE HIND FOOT OF THE HORSE.

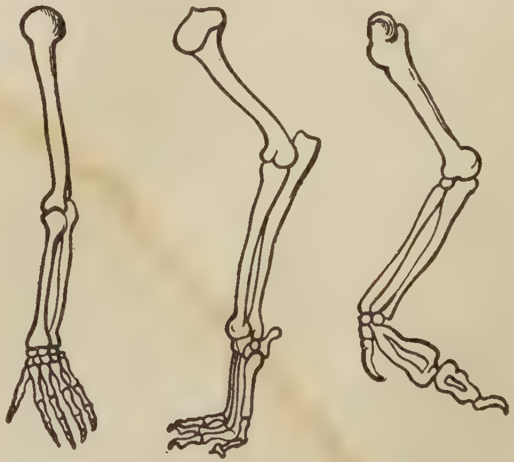
The earliest known fossil horse had three toes on the hind foot (left). The gradual loss of the two hind toes and the traces of them in the modern horse can be clearly seen (right).

their ears to rid themselves of flies, and they set them in a certain direction the better to listen.

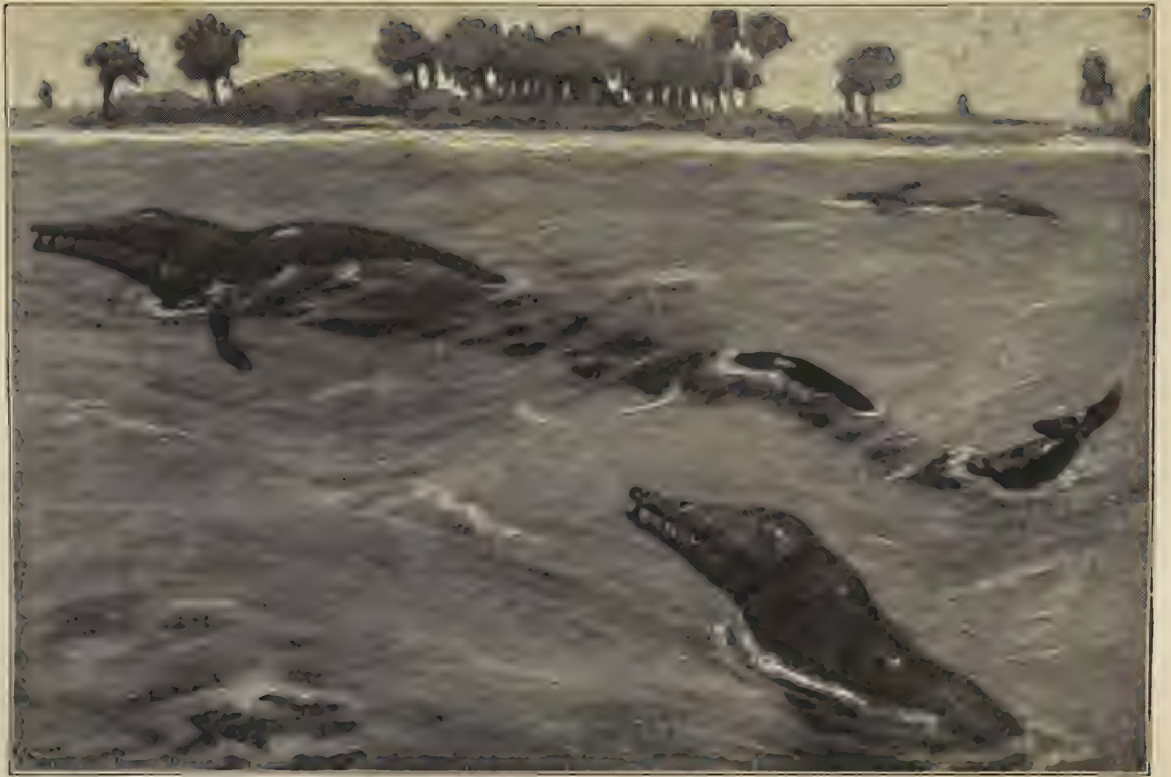
In men they are rudimentary, barely present and serving no useful purpose. We speak, figuratively, of "pricking up our ears" when we listen acutely. But nobody can do so. A few thousands of years ago, man the hunter, living wild in the forests, could doubtless "prick up his ears" literally, like any horse or dog. There is often another vestige in the ear itself. Run a finger around the extreme edge of the ear at the top, where it turns inward upon itself. You may find a tiny projecting point that is clearly present in many ears. The ears of the lower animals are pointed, and this small projection is left over from these pointed-ear ancestors. The vermiform appendix is another illustration, a once useful structure having here become positively dangerous. Man has got completely rid of his tail so far as external appearances go, but the anatomist finds bones that are unmistakable remnants of it at the end of every spinal column.

There are countless examples in animals. Snakes generally have no sign of a leg; but the python has vestiges of hind legs; and how did he get them except upon the theory that he is descended from the ancient reptiles with legs and has lost them through non-use? The whale has fore legs which he uses as paddles; as far as appears externally he has no hind legs at all. But rudiments of them are to be found hidden under the skin. If the whale's ancestors crawled out on dry land, developed four legs, and then took to the sea again, where they needed only flappers and a tail, the presence of these mysterious remnants is no mystery at all. But how else explain them?

The comparison of the structure of existing animals yields far more elaborate conclusions. Take these same flappers of the whale which he uses as paddles. They are built on exactly the same plan as the arm of a man or the fore leg of a horse or the wing of a robin—the same joints, the same bones. It is difficult to explain this extraordinary resemblance except upon the evolutionary basis that all are descended from a common ancestor whose fore leg was, in the course of millions of years, adapted to swimming, trotting, flying, writing.


THE ARM OF A MAN, THE FORE-LEG OF A DOG, AND THE WING OF A BIRD COMPARED.

Such adaptation seems a little unreal when applied to organs thus completely specialized—a hand holding a pen and a wing soaring aloft. Fortunately, similar processes are at work to-day. Charles Darwin took much of his proof from the cases of domesticated animals, the breeding of which he studied for years. For one clear illustration he showed that the wings of the wild duck are larger than are the wings of



Courtesy American Museum of Natural History.

THE ZEUGLODON, A WHALE-LIKE LIZARD NOW EXTINCT.

The zeuglodon was first a land-living animal descended from an arboreal ancestor. About 3,000,000 years ago it underwent a rapid reversed evolution into the eel-like mammal shown here.

From a painting by Charles R. Knight.

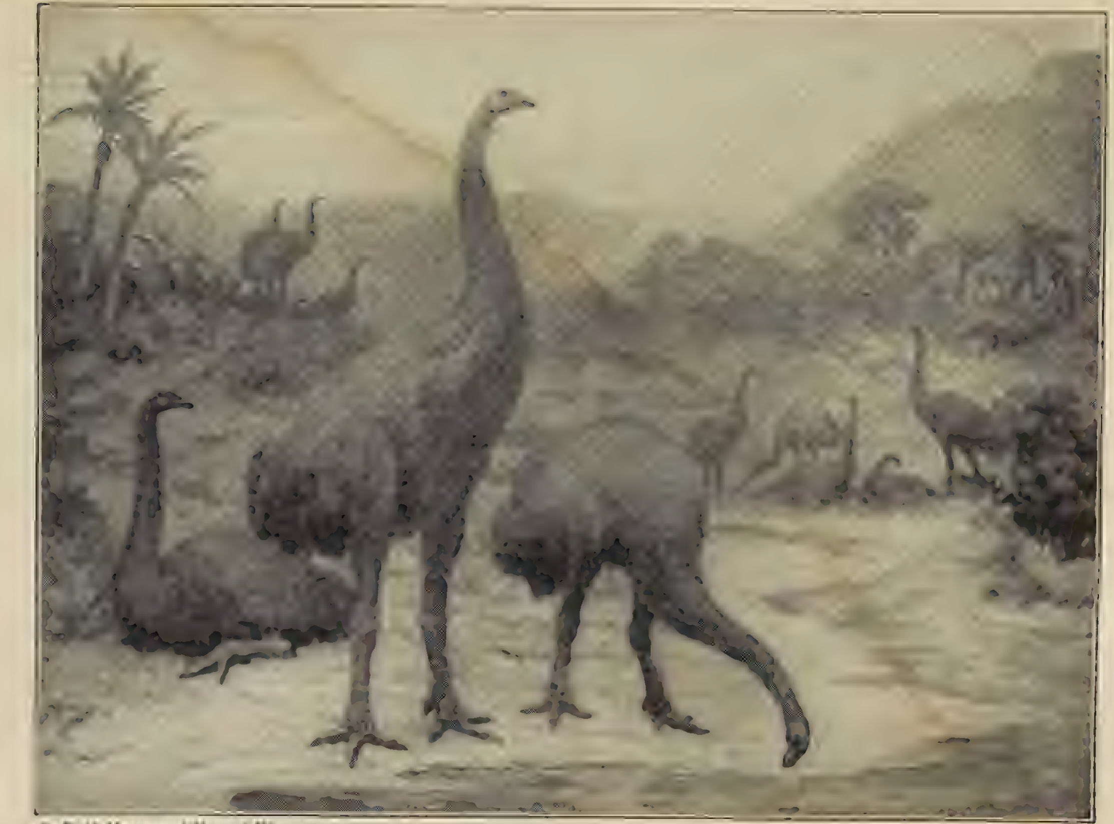
the domesticated duck, larger in proportion to legs, that is. Surely, this is easy enough to understand. Yet continue the same process, keeping the domesticated duck closely confined, unable to fly, for a million years, and is it any more difficult to conceive that his wings might cease to be wings altogether, might even disappear within his skin like our tails or the hind legs of the whale? (There is actually a bird in New Zealand, the apteryx, which has wholly lost its wings.)

This modern parallel covers only part of the fact, however. The wings of a duck disappear from non-use—atrophy, in technical phraseology, literally, lack of nourishment. From what did the first wing develop, or the first leg, or the first back-bone, or the first anything? This goes to the heart of the evolutionary problem and touches the chief weakness in the Darwinian explanation.

It may seem at first glance as if this question might have a simple answer. Take the giraffe, for an obvious example. What could be easier than to suppose that he developed his long neck by stretching up to get the foliage of tall trees? Start at a time when the ancestors of the giraffe had necks of ordinary length. Then through some gradual change in the climate it became necessary for them to seek their food higher and higher. The first pair of giraffes thus put to it stretched their necks a little; their children inherited the extra length of neck and stretched their necks a little more; and thus, bit by bit, the present extraordinary neck was achieved. That is probably the first explanation of evolution which suggests itself. It was the theory put forth by Lamarck, the French naturalist who preceded Darwin. It is simple and clear.

Unfortunately, there is a serious objection to it, an objection which may seem strange at first sight. This is that there is no satisfactory evidence whatever that the second generation of giraffes would inherit the long necks their parents formed by reaching aloft. Man is so familiar with the constant workings of inheritance, with the fact that children resemble their parents (whether the parents are humans or horses or giraffes), that he seldom makes this distinction which to the biologist is all-important. Children do resemble their parents; this is one of the solidest facts of life. But do they resemble their parents in respect to those qualities which the parents have acquired? Is the son of an acrobat born with the muscles of his father? Does a trained seal in a circus give birth to little seals which possess the tricks or the cleverness of their mother? Suppose you cut off the tails of a pair of mice with a carving-knife, as in the rhyme, will their descendants tend to be tailless?

When this extreme case is reached, it is easy to guess that the answer will be no. But what of the other cases? There is endless evidence upon the question in the books on evolution. It is called the question of the inheritance of acquired characteristics. No final answer has been reached. It may be that there is in certain cases such an inheritance. The difficulty of proving a negative is great. But the evidence runs



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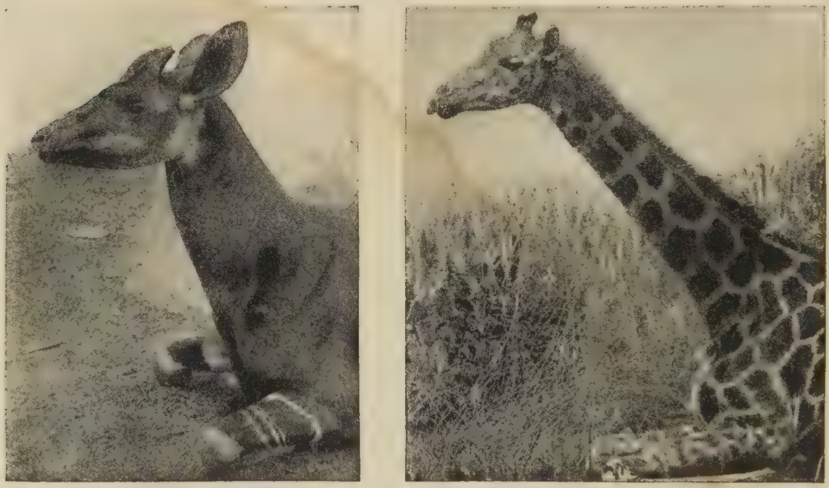
THE MOAS OF NEW ZEALAND, WINGLESS BIRDS WHICH RECENTLY BECAME EXTINCT

From a painting by Charles R. Knight.

strongly against such inheritance. It may be said with confidence that there is no sufficient evidence as yet to prove this essential proposition of the Lamarckian theory.

How, then, did the giraffe's neck become longer and longer? Here was the great service of Darwin. He conceived a theory by which, without inheritance of acquired length of neck, the gradual elongation of the neck would take place. Darwin called his theory, as already stated, "natural selection"; but it is perhaps better known under the name which a later English evolutionist, Herbert Spencer, gave it, "the survival of the fittest." It is a theory that would operate far more slowly than would that of Lamarck. But it would operate just as surely. It regards the huge number of offspring which animals bring into the world, and notes the fashion in which they vary. It observes that there is on the part of these varying offspring a hard struggle for existence—not an actual fight between children, but a competition for food, shelter, etc. All cannot survive; especially among the lower animals far more perish than live; which will these fortunate survivors be?

To return to the giraffes. Of the first pair confronted by the ascending foliage, there would be born young giraffes varying considerably in length of neck among other qualities. Such variations are universal, as every human family shows. Now some of these giraffes would be better fitted to the changing condition of their region than others—to their environment, in more technical phraseology. Let us assume that here it would be the baby giraffes with the longest necks that would stand the best chance of living. (The sum of a great many qualities would decide, really, for the question of which animal is the fittest depends on the sum of his qualities; but the case can be thus simplified by way of illustration.) The giraffes with the shorter necks would tend



EXAMPLES OF ADAPTATION DUE TO THE SURVIVAL OF THE FITTEST.

The short-necked okapi (left) browses upon the lower branches of trees, the giraffe (right) on the higher. The okapi is adapted to forest-living and the giraffe to plains-living.

to die off. Now see what the effect of this would be upon the next generation. The long-necked giraffes, surviving, would have offspring, and these young giraffes would tend to inherit the long necks of their parents, since these long necks were born in them, not acquired. The short-necked giraffes would die and leave no children. Thus, simply as a result of accidental variation and the struggle for existence, the neck of the giraffe would constantly tend to become longer. The environment moulds, according to Lamarck; it selects, according to Darwin.

The foundation laid down by Darwin has not been shaken by criticism. Natural selection is still generally accepted as a major factor in evolution. But long study has revealed the fact that the problem is not as simple as the first advocates of the new theory believed. It never is, in science! Natural selection can be accepted as the great eliminator; it has sifted out the unfit and constantly tended to preserve the fit. It is far from established as a sufficient explanation of all evolution. In fact, there is a growing tendency to seek out other principles to supplement it. Darwin, himself, saw the need of other factors; he stood ready to apply the Lamarckian theory in certain cases.

Of the many criticisms of the Darwinian theory, one of the most serious is the one already suggested as to how the first leg, the first eye, or the first anything starts. The ordinary differences between offspring are inconsiderable. How can it be conceived that the first chance beginning of a new limb, for example, would be of any value whatever in aiding its possessor to survive? Might it not rather be a detriment? And unless a variation is useful, then and there of positive every-day value, the Darwin theory does not explain its survival.

In aid of the Darwinian point of view, the most important idea that has been evolved is the work of a Dutch botanist, Hugo de Vries. Thus far illustrations of evolution have been drawn from the animal world. But the principles are not less true of plants and flowers, and the work of botanists and biologists has been of prime importance to evolutionary theory. De Vries conducted a long series of experiments with one plant, the evening primrose, in an effort to determine just how great are the accidental variations upon which the whole theory of natural selection rests. Darwin conceived of these as slight, and of evolution as a very slow process, proceeding by almost invisible changes. Now De Vries found that his evening primrose showed startling changes in each generation of seeds. Plants exactly like the original stock were much the more numerous. But at least one in perhaps a hundred would be very different; and (here is the second important point) these extreme variations bred true—that is to say, from the seeds of these strange primroses grew the same strange flowers.

Such variations have long been a matter of common knowledge among plant-growers and animal-breeders. They are called "sports." What De Vries did was to prove their occurrence as a scientific fact and to prove that they breed true. He named these strange seedlings "mutations." It is obvious how this discovery applies to evolution. Instead of slight variations to select from, there is the possibility in each generation of a few exceptional specimens possessing extraordinary qualities. When these strangers happen to fit their environment, there is a possibility of a long and sudden jump in evolution. That is, indeed, the way in which De Vries conceives of evolution, as a succession, not of infinitely minute changes but of considerable leaps. The origin of new organs, of legs or what-not, is more easily conceived by the aid of such "mutations."

A word of caution is necessary as to this theory. It rests chiefly upon the experiments mentioned with the evening primrose. Before it can be accepted, it must be confirmed by much other research. Until this confirmation comes, it is to be viewed as only one of many hypotheses which may some day be firmly established in the evolutionary theory. It is worth citing for its possible importance and for the excellent illustration it gives of how slowly and by what lifetimes of precise and delicate observation scientific progress is gained.

As a matter of justice, there must be mentioned with the name of De Vries that of Mendel, an Austrian monk who experimented along similar lines and with the same patient care a half-century earlier. Mendel discovered certain laws of heredity in 1865 which bear a distant relation to the conclusions of De Vries reached in 1900. (The work of Mendel had been published and forgotten all those years.) He proved that certain characteristics of peas (ordinary edible peas) tend to disappear for generations, to reappear suddenly as if from nowhere; and he reduced his conclusions to an exact mathematical formula. In recent years his laws have been applied to many organisms, to wheat and barley, to mice and chickens and cattle, among others. They are in constant use to-day by seed-growers and animal-breeders; for they make it possible to secure stock which will breed true, that is to say, never produce sports. It is of course the reverse of this process which is of interest to evolutionists. For the Mendelian laws show that a certain type of sport is a necessary and frequent event in nature where there is a mixed ancestry. (The mutations which De Vries discovered may probably occur in pure stock.)

One school of evolutionists, the later Darwinians, seek to explain evolution by the one principle of natural selection, or, at any rate, regard that principle as the controlling factor. In contrast with them are a number of scientists who have sought proof of the existence of some inborn tendency in living matter to develop. They accept natural selection as the sieve through which nature selects those forms which are to survive; for the source of variation, of change, of development, they look elsewhere. They do not agree literally with Lamarck's statement that the giraffe got his long neck by wanting a long neck and stretching the neck he had for many generations. In this simplest form there is not much belief in the Lamarck theory to-day. For, as has been seen, this conception presupposes the inheritance of acquired characteristics for which there is no good evidence. But these critics of natural selection, under a wide variety of hypotheses, all tend toward the Lamarckian view of progress as something flowering from the structure of the organism itself, not simply the result of chance variation. The neck of the giraffe grew long, they would say, because there was in the cells of the animal something which made them respond to this need. In its extreme form this view reaches the point of view of those vitalists who would explain the appearance of life upon the earth by the advent of a new and as yet undetermined force. The two problems are closely related; are, in fact, almost one problem. If man ever understands exactly what life is, he will probably comprehend evolution fully.

As the problem stands at present, there is, thanks to Darwin, a clear explanation of the negative side of evolution, the fashion in which nature eliminates the unfit and selects those who are to survive. Man cannot feel sure that he knows how nature originates those various forms between which she thus chooses. Are they the result of chance? Or are they the result of an inborn tendency? That is where the problem of evolution stands to-day. A brilliant progress has been won, undoubtedly the longest leap the human mind has ever taken. But a profound mystery has been revealed which is still wholly unsolved.

2. THE TREE OF LIFE

Before setting down the story of evolution in order of time, one other fact should be made clear. That is the first branching of the tree of life, at an early stage, into plants and animals. The old division of the world into three kingdoms—animal, vegetable, mineral—does not accurately express this result. For, whereas the mineral kingdom can be taken as describing a true division, that of the non-living, animal and vegetable are really halves of one kingdom, the living. But the old division is none the less right in making a sharp distinction between plant and animal. Just what is that distinction and when did it first appear upon the earth? Which appeared first? It is natural to guess that plants came first, and that animals developed from them. Is this view borne out by the facts?

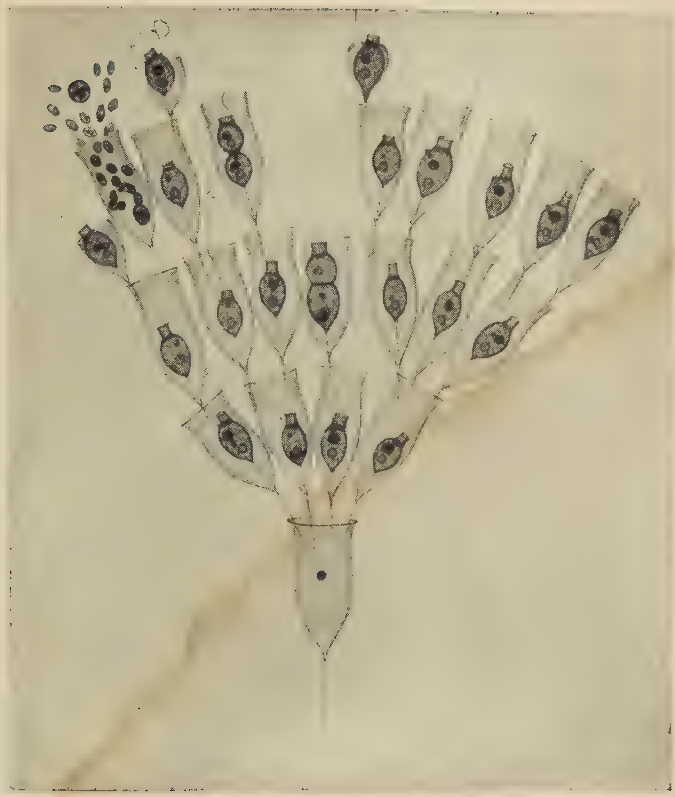
There can be no certain answer to the question of priority. The division took place in the farthest mists of Archean time. There is no clear proof that the plant appeared before the animal, and many scientists are working upon the hypothesis that they developed side by side out of one substance, the most primitive living matter, their common ancestor. One thinks of animals as more complicated than plants, as superior to them. But the most primitive animals closely resemble the most primitive plants. In fact, there are many small organisms, the bacteria, for example, which it is difficult to classify, which have not made up their minds whether to be plants or animals. Whether their existence supports the view that plants and animals started life together, or the view that animals developed from plants, it makes the fact clear that their separation, their becoming different from one another, constituted the first great step in the evolution of life.

Man's very existence depends upon that difference. The plants of the earth could live on if all the animals were destroyed, would, indeed, grow more lavishly with no animals to devour them. But if all the plants of the earth should disappear, every animal would swiftly perish. Such is the plan by which life on the earth has been developed. It is perhaps the most wonderful of all the many delicate adjustments that hold the universe together and have made possible such complex creatures as man.

What the plants do for animals is to take the rays of the sun and transform their energy into animal foodstuffs. One may conceive of the whole vegetable life of this earth as a vast factory for bottling the energy of the sun's light and heat to be served in mangers and on dinner-tables. The fashion in which this is done is delicate and ingenious. The leaves of trees and plants resemble photographic films in that they are most sensitive to light. Just as light makes a picture by setting up chemical changes on an exposed film, so light works chemical changes in the leaves. It enables them to take carbon from the air and build of it complicated substances like sugar, starch, and fat, the chief foodstuffs. How this is done is not yet fully understood; but the substance in the plant which does the work has been identified and closely studied. It is called chlorophyll, which is Greek for "leaf-green," and it is, in fact, nothing else than the green coloring matter of leaves. It is thus for a very practical reason that a willow-tree turns green in the spring. The color is not mere decoration. Wherever it is present, there is going on this extraordinary chemical process without which plants would die and, in turn, animals starve to death.

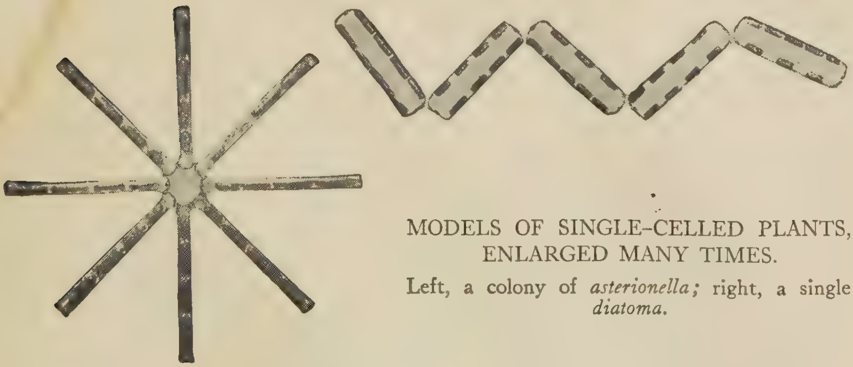
The resemblances between plants and animals are many. A boy and an apple-tree are not as different as appears on the surface. Both are built of similar cells of living matter. Both are born, grow, and will some day die. Both breathe. Both eat and digest. But it is precisely in this matter of eating that the great difference exists. The chlorophyll of the apple-leaves acts as the tree's stomach, if you will; with the power of sunlight it separates carbon from the air and therewith feeds the body of the tree. The boy cannot eat carbon from the air. Yet his body is built of the same carbon products as the tree, and must feed upon them or die. So he eats an apple or a piece of bread; and his stomach is built to digest these prepared foods. He eats the carbon of the air and the energy of the sun second-hand, already half digested, as it were, by the tree and the plant.

Here is the fundamental difference between plant and animal, running back clear to the simplest forms. There are a few queer animals which possess the green-making faculty. There are a number of vegetables, the fungi, which do not possess it, living as parasites on other vegeables. The general truth of the distinction is clear. And closely connected with it is the other great distinction clearly illustrated by the boy and the apple-tree. The boy can climb the apple-tree; the tree cannot run away. Animals, even of the simplest form, move; the amœba, as has been noted, pulls him-



TYPICAL SINGLE-CELLED ANIMALS, A COLONY OF FLAGELLATES, ENLARGED 430 TIMES.

The whip-like organs are used for locomotion.



MODELS OF SINGLE-CELLED PLANTS, ENLARGED MANY TIMES.

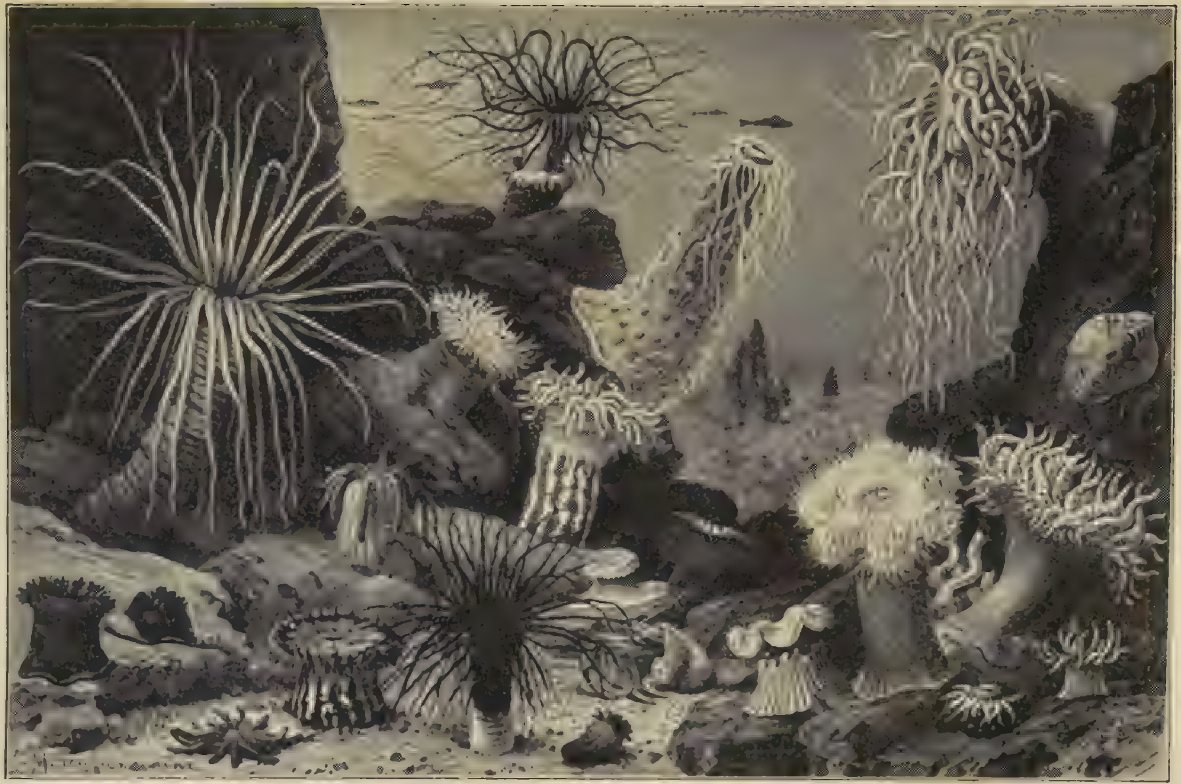
Left, a colony of *asterionella;* right, a single *diatoma.*

self along by his stomach. Plants make certain slow gestures, turning toward the sun, for example; their general nature is to stay put. They are the placid, stay-at-home part of life. Theirs is the calm and silent labor of sitting still and storing energy for the restless, stirring beings of the earth, the animals. It is possible to conceive of a quite different development of life, of vegetables that could walk, or animals with green leaves. Evolution early took the double road. The result has plainly been to relieve animals of part of the burden of life, to supply them with energy, ready for use, and thus to begin life at a freer and higher level than that of the plants. That is why history is almost wholly a history of animals and only passingly a history of vegetables. That is why vegetable life reached its full development long ages ago, while the swimming, leaping, roaring animals have gone on from one adventure to another, are still going on in the story of their most complicated achievement, man.

In the following story of evolution the main divisions of geology will be followed. Of course, these are wholly artificial boundaries. The stream of life has risen and fallen, profoundly affected by the changing face of the earth; but it has never halted, and each age flows imperceptibly into the succeeding.

Archean Life. There is some direct evidence of life in the rocks of this era. Its extent and character are wholly matters of inference. There must have been life through a large part of these 250 or more million years, and many forms of it must have been developed, because when the fossil record begins in the next era the scientist finds himself at once in the presence of a great variety of creatures. Their long line of ancestors is lost because they lacked bones. Not much progress has been made in reconstructing that ancestry by reasoning backward. Theories as to these early forms of life are suggestions rather than facts. Not much more can be said than that this is the way life may have developed.

In the long millions of years which form the Archean Age, had a visitor from another planet flown into sight of the earth he would have hurried past, dismissing it as a hopelessly bleak and desolate shore. Where upon the earth life was beginning remains hardly more than a rough scientific guess, a first hypothesis based upon probabilities, and serving only as a temporary chart for investigation and research. One must be careful to attach to this hypothesis only the importance which men of science give it. Purely as a working hypothesis, then, it may be said that life probably first appeared along the shores of the waters of the earth. There all the necessary chemical elements were present. There where the heat of the sun lay warm upon the shallows it is easiest to conceive that this most extraordinary event in the evolution of the earth took place. A majority of scientists are working upon the theory that life originated in the salt seas; others look to the fresh-water pools of the earth. The whole subject is still as vague and dark as the form of that first



Courtesy American Museum of Natural History.

SEA ANEMONES WHICH, ALTHOUGH THEY LOOK LIKE FLOWERS, ARE REALLY ANIMALS RELATED TO THE CORAL GROUP.

earth, heavy with clouds, lashed by tempest, and lit chiefly by the fiery tongues of volcanoes.

The first life, it is supposed, was far simpler than the simplest plant or animal now known. After all, as some one has said, even the amœba is no fool. He knows how to go after desirable objects, food, and to go away from danger. The microscopic one-cell animals and plants, the bacteria, and so on, are thought of as the descendants of a mass of living matter, perhaps a sort of jelly feeding and growing but hav-

From a photograph by Ewing Galloway.

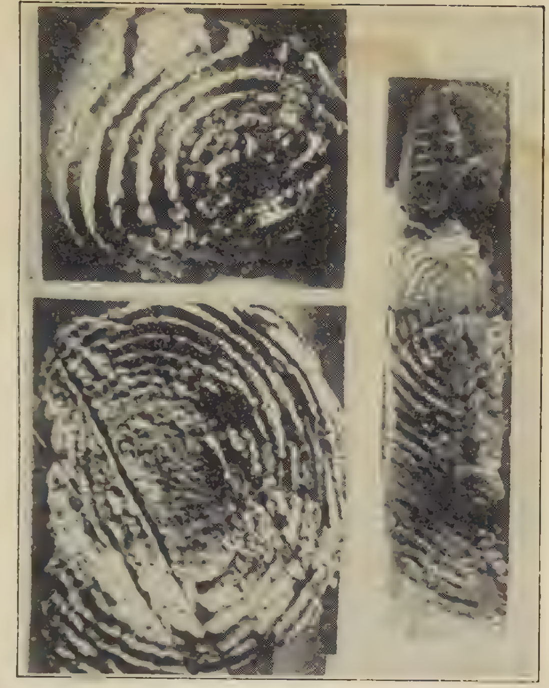
THE FORBIDDING NORTH CAPE, NORWAY, IS NOT UNLIKE THE DESOLATE EARTH OF ARCHEAN TIMES.

ing neither cells nor anything resembling an individual existence.

The one-cell animals (like the amœba) and the one-cell plants (like the simplest algæ or seaweeds) would be the first living creatures under this hypothesis. Along each line of descent, the one-cell creatures developed into simple groups of cells, and these, in turn, into organisms containing many more cells, arranged upon a plan, exceedingly simple, which enabled certain cells to do one thing and other cells to do another—as in the coral, for instance, a belly with a mouth and nothing else.

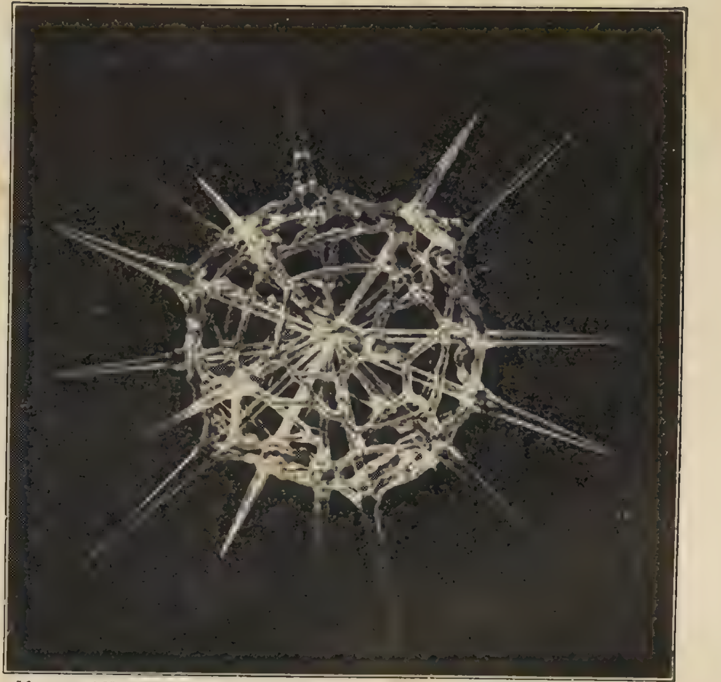
When fossils appear in the next era, the Paleozoic, there is this striking fact: all of the subkingdoms of animal life, including 500 and more species, are present save only the vertebrates. Therefore, it is certain that life was abundant and of many forms before the end of the long Archean era. There is one important restriction. So far as the evidence shows, it was limited to the seas, the lakes, and the rivers. There is no suggestion of animals on the land or of trees or turf. It is likely that throughout this vast period, one-half of the earth's life, the soil and rocks of the earth were as barren as a desert. For 250 million and more years life surged and floated in the waters, and the dry land knew no least living thing.

In this slow-moving period of incubation the bacteria, the simple scum-like seaweeds, the one-celled animals like the amœba, were surely present. Later the seas must also have



FOSSIL ALGÆ OF THE ARCHEAN ERA.

These fossils are an important constituent of some very ancient limestones, especially in the Teton hills.



Courtesy American Museum of Natural History.

SKELETON OF THE RADIOLARIAN ENLARGED 300 TIMES.

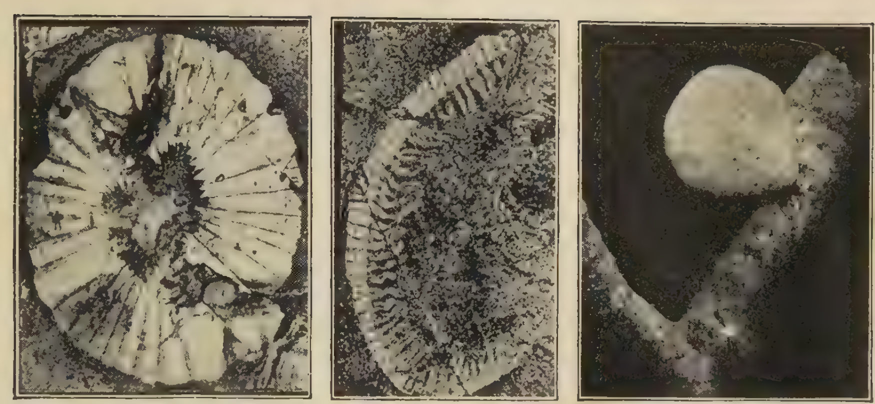
It floats on the surface of the sea, and owing to their great numbers these tiny skeletons are an appreciable factor in earth-building.

held many such animals as the sponges, the sea-anemones, and the jelly-fish; and toward the end it is certain (from burrows preserved in the rocks) that the achievement of the worm was reached. This was an epoch-making advance, because the worm, or some animal like it, was the first creature with a brain. The earlier animals, like the jelly-fish, have what is called radial symmetry. That is to say, they radiate from a centre like an orange; they have no left or right, no head or tail, as befits their sluggish drifting manner of existence. To lead a more strenuous life, to pursue and to escape, a right and left side, a head and tail, are as essential to an animal as to a boat. The worm was such an animal. It had no back-bone—it was millions of years yet before that achievement was won by the fishes. But it had a brain, for with the development of an end that tended to be in front, came the simplest, most primitive head and brain, a nerve-centre that to some extent received impressions and transmitted orders to the several parts of the body.

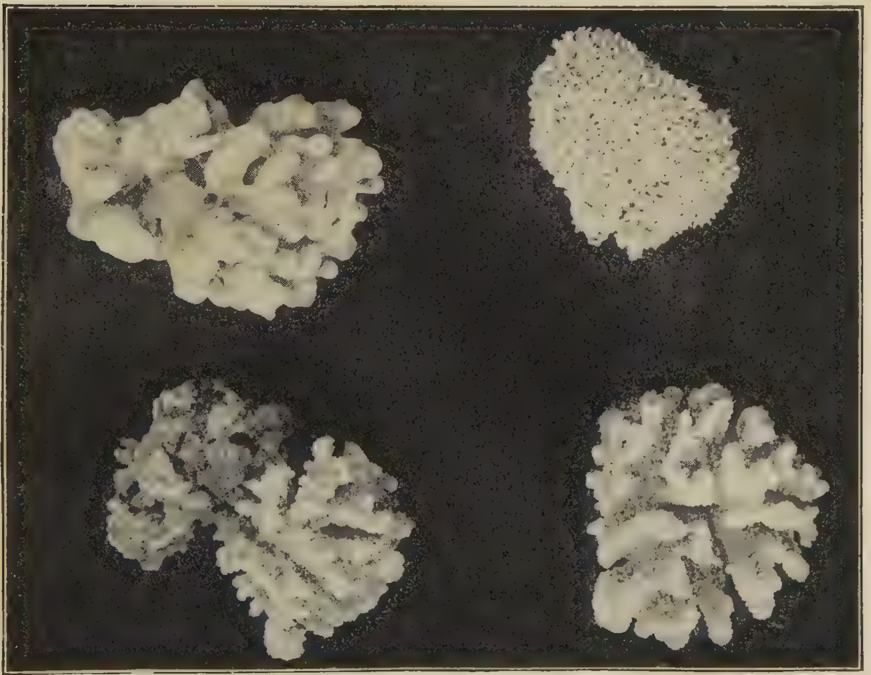
Paleozoic Life. Five great developments took place in this era. The plants spread over the face of the earth, largely in the form of giant ferns. The fish developed its back-bone. Toward the end, certain adventurous fishlike animals climbed out on the dry land and developed into frogs and other amphibians. At about the same time certain crablike animals grew wings and were insects. Finally appeared the first reptiles that were to grow to such enormous size and dominate the entire Mesozoic era that was to follow. To a visitor from another planet the conspicuous features at the height of this long era—almost a third of the life of the earth, or not less than 150 million years—were plain. It was, above all else, the age of fishes and ferns.

Throughout the first part of the era the oceans were ruled by a strange animal that rose to power, declined, and disappeared, all within this era—the trilobite. The name means that he had three lobes or parts. Most of these animals were small, an inch or two long; but there were giants as long as two feet. The horseshoe crab of to-day (which is not really a crab at all) suggests their general look; and one can form a rough idea of the earth at this time by picturing it as ruled for millions of years by horseshoe crabs. But from the point of view of the amœba an enormous advance had been made. The trilobite was a miracle of highly specialized organs by comparison. His eye was wonderful by any comparison, being compound, like the eyes of insects. The eye of the trilobite sometimes possessed as many as 15,000 lenses. From an animal that walked with his stomach to an animal who could boast of 30,000 eyes was no short march. These vast ages when all life was underseas were by no means waste or idle.

There were starfish and sea-urchins, there were oysters and clams, there were snails, conches, and periwinkles in the early Paleozoic seas—not exactly the modern forms, but plainly their ancestors. Corals developed apace. The fossils of 950 distinct species of trilobites have been found existing



FOSSIL JELLY-FISH, WORM, AND LAMP-SHELL, FOUND IN EARLY PALEOZOIC ROCKS.



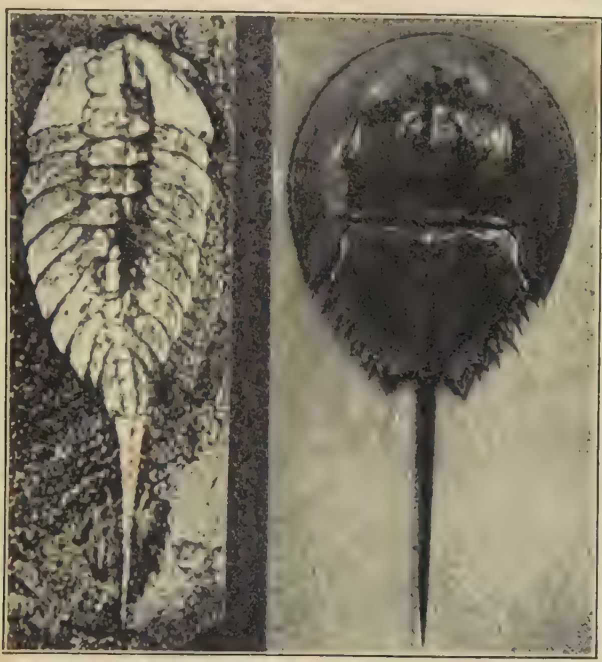
Courtesy American Museum of Natural History.

FOSSIL CORALS FROM THE EARLY PALEOZOIC.

These fossils are representative of some of the sub-kingdoms into which invertebrate life has been divided. Their descendants can be found living in the ocean to-day.

at the time of their greatest development and fully 7,000 fossil species of lamp-shells.

About the middle of the era came its two most important



Courtesy American Museum of Natural History.

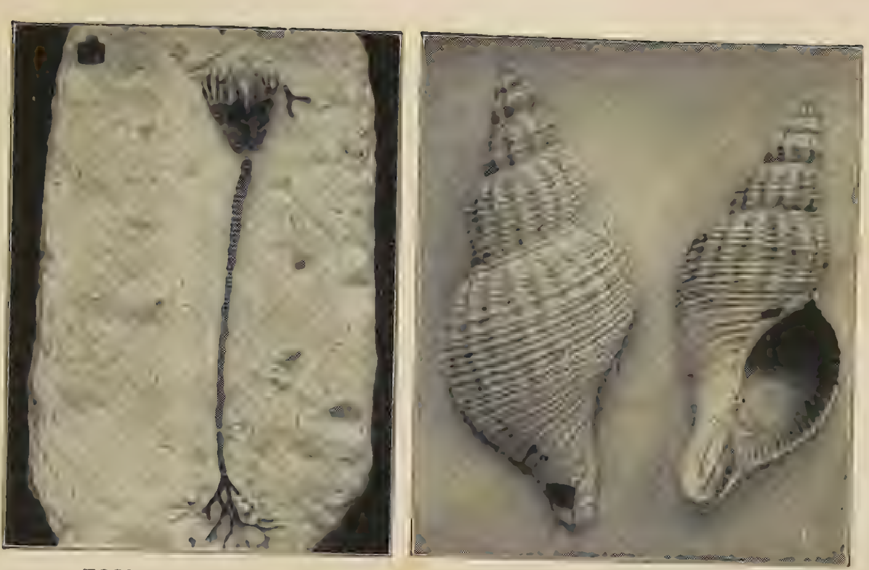
THE HORSESHOE CRAB (RIGHT) AND ITS CAMBRIAN ANCESTOR, THE MEROSTOME (LEFT).

The resemblance shows plainly, although the merostome has long been extinct.

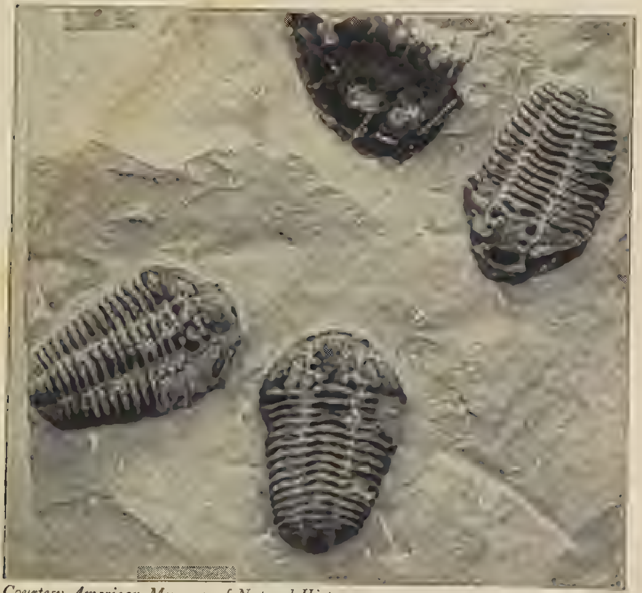
events. Together they made this age perhaps the most significant in the story of evolution. The back-bone appeared in the fish, ancestor of the whole line of land vertebrates destined to rule the world; and, as a forerunner of the invasion of the land from the sea soon to begin, the earth was carpeted with green food without which animals could not have lived ashore. These were completed facts by the time full evidence of them is preserved in the rocks, and it is certain that each had a long prior history. The record of the fish's back-bone can be traced back a certain distance, but its exact ancestry is a matter of speculation. In any event, it is probable that the first beginnings of a back-bone came early in Paleozoic time. The other great event, the appearance of fern-like forests upon lands, must equally have grown from small beginnings. The continents may well have been covered with verdure of some kind from the beginning of the era. But just as the first back-bones were not sufficiently heavy to be preserved as fossils, so the first vegetation vanished beneath the rocks, leaving hardly a trace.

The sharks were among the first of the fishes. They were small and mild, not at all like their modern descendants. The armored fishes had preceded them, some small and sluggish, absurd creatures, others large and terrible, the masters of the sea in this age of fishes. All these heavy fishes, the battleships of marine life, proved to be a start in a wrong direction. They all died out within a few million years, beaten in the struggle for existence by the light, swift-moving fishes. There were many other strange wanderers in the sea at this time. The most interesting is the lung-fish, for it gives a vivid illustration of how evolution proceeds.

There are three species like the ancient lung-fish that have lingered on to present times. One lives in the stagnant river-waters of Australia, where drought is a constant peril and a



FOSSIL SEA-LILY (CRINOID) AND CONCHES (GASTROPODA).



Courtesy American Museum of Natural History.

FOSSIL TRILOBITES (ARTHROPODA).

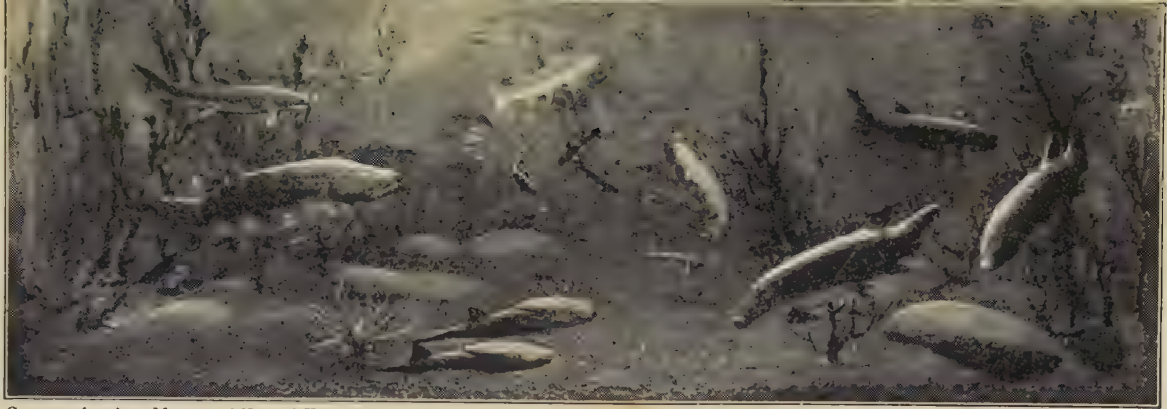
These early Paleozoic fossils are members of the higher sub-kingdoms of invertebrate life. *Arthropoda*, a class which includes all crustaceans, spiders, and insects, may be the ancestor of the vertebrates.

fish is hard put to it to breathe through his gills. There is another lung-fish in the Nile, still another in the Amazon. All these fish can breathe in two ways: by gills, like ordinary fishes, and also by a lung. When they want, they can rise to the surface and breathe the air exactly like a dog or a man. Now, this lung exists in most fishes, but it is altered to serve a quite different purpose. It is called a swim-bladder, and by squeezing air out of it or sending air in, a fish can maintain any level in the water he desires without effort—just as a submarine pumps out or lets in water to rise or sink.

Scientists have not yet found the fossil ancestors of these fishes. But evolutionary theory conceives that this lung developed in fresh-water fishes in a time when the lands were rising and waters shallow and stagnant; that in the lung-fishes it survived somewhat in its original form; that in other fishes it altered into a swim-bladder; and that in other animals of the sea it developed into true lungs that enabled the first amphibians to walk out upon the shore and become the ancestors of the whole vast land army of vertebrates. The lung-fishes are not the ancestors of man, but they point to a common ancestor as yet undiscovered in the rocks.

While all this was happening afloat, while lungs were building beneath the sea whereby the great invasion of the land was soon to follow, the whole face of the earth was changed. Pushing up along the marshes, then spreading to the highlands, appeared the first forests. Rushes, ferns, and evergreens are preserved from this middle period of Paleozoic time, with ferns conspicuous. The same forests stretched throughout eastern North America and northwestern Europe; for in this period the continents were united via Great Britain and Greenland. Already there were many species of each plant and already the two great divisions of plant life had been evolved—the plants that reproduce by spores (like ferns and mushrooms) and the plants that reproduce by seeds (like trees and flowers). From the spore of a fern there grows not a fern but a short-lived plant that develops the cells of a true fern and then dies. From a seed there grows at once the plant from which it came. The spore system is a clumsy, slow method, and the seed marked a great advance. Only one step remained to complete plant life and that was the development of the flower. This probably did not come till the next era, the Mesozoic. But the seed was the great achievement, the flower came only as a refinement; and it may be said that the vegetable world thus reached its limit of evolution, in essentials, at this early date, not less than 125 million years ago, while animals were still restricted to the sea, and such great improvements as marked the mammals were still far distant. Thereafter the development of plants was chiefly in the multiplication of varieties.

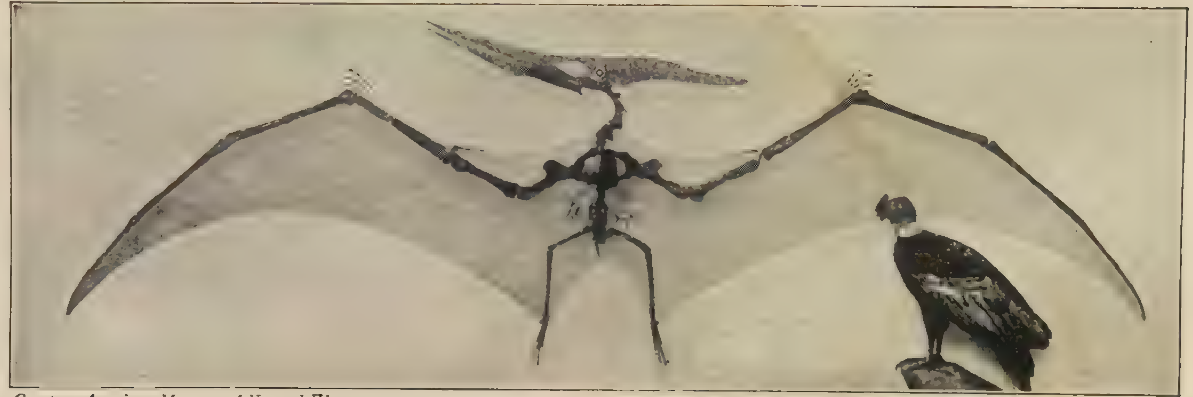
The spread of the great ferns and evergreens was swift in the closing periods of Paleozoic time, and they formed the setting, dense, tropical, and eerie, for the three great events that came together in the last third of the era. This was the age of coal; it is these luxuriant forests of fernlike trees that,



Courtesy American Museum of Natural History.

RESTORATION OF TYPICAL FOSSIL FISHES.

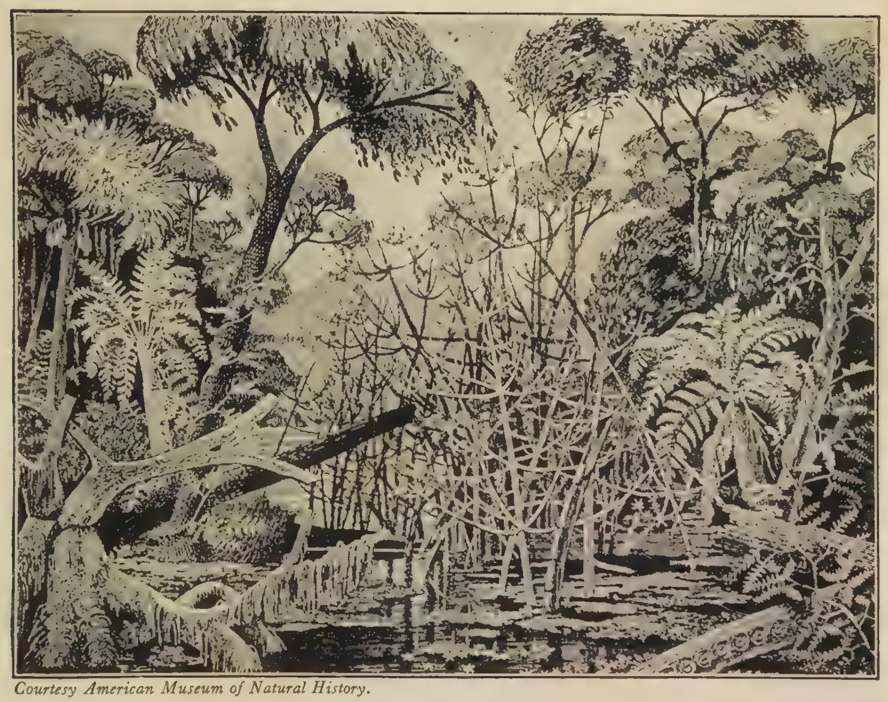
The small fishes in the centre are sharks, those at the right lung-fish.



Courtesy American Museum of Natural History.

A FLYING REPTILE, THE PTERANODON, COMPARED TO THE MODERN CONDOR.

fallen to the ground and buried beneath later rocks for many ages, man burns in his stoves to-day. It might be called also the Age of Cockroaches, for in these forests appeared the first insects, strange and gigantic. There were dragon-flies two feet from tip to tip of their wings; and there were above all else cockroaches, 500 species of them, some of them four inches in length. These ancestral cockroaches and other primitive insects were amphibious, and it is thought that they were descended from the trilobites once lords of creation,



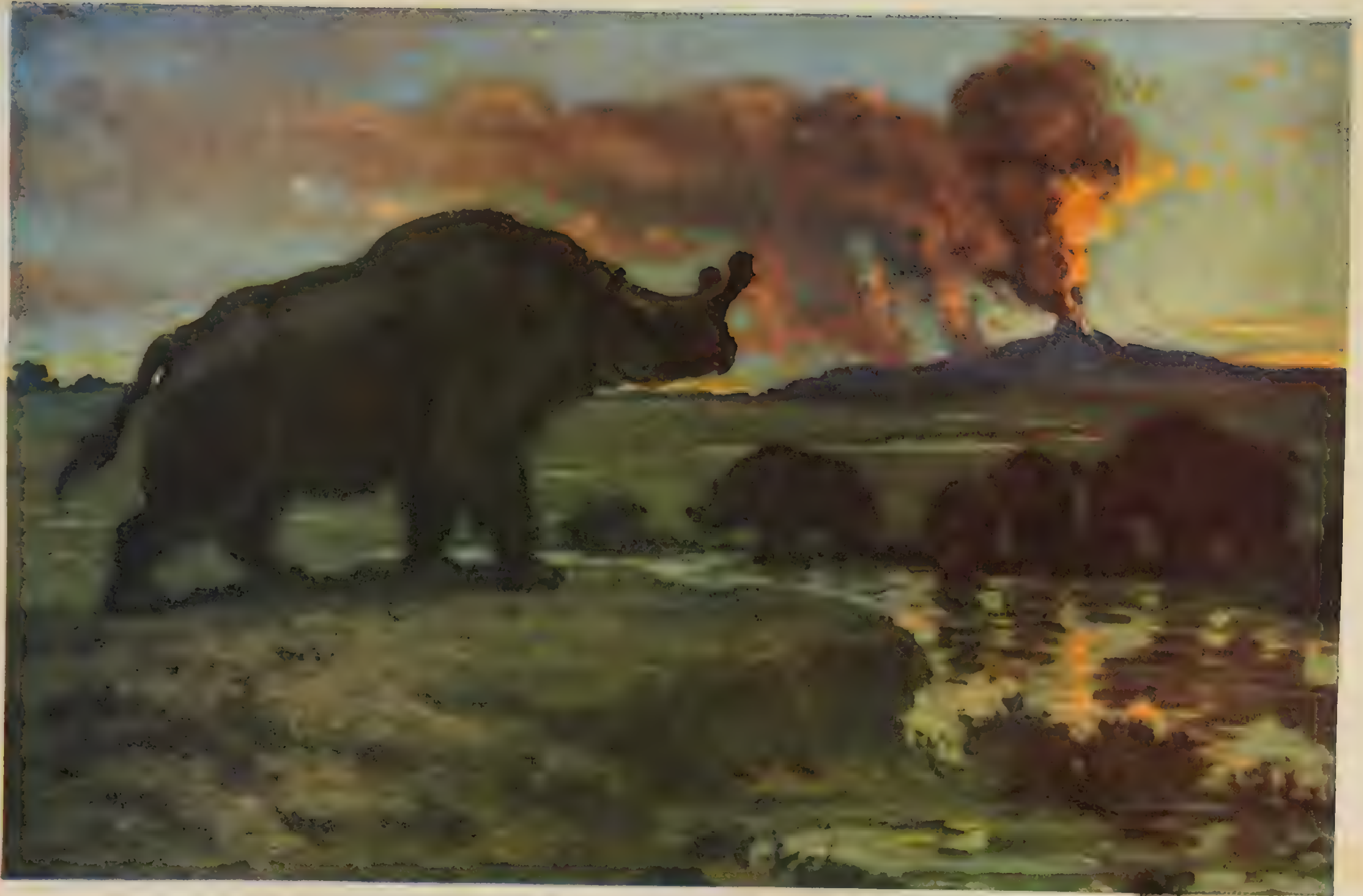
Courtesy American Museum of Natural History.

COAL IS MADE OF FORESTS SUCH AS THIS, DECAYED AND SUBJECTED TO PRESSURE.

The huge fern-like trees of the coal-measures exist to-day as horsetails, club-mosses, ground-pine, etc.

now disappearing from the face of the earth. But this is only a surmise. The links in the chain are missing and it is impossible to reconstruct with any confidence the story of how the insects developed their wings. It is certain only that they were closely related to the trilobites and to all the crustaceans, and that they appeared thus early upon the scene, sharing with the amphibians the honor of being the first land-animals. They are thus an entirely different branch of development from the other animals that share their habitat, the birds. Wings were developed for the insects in the last half of Paleozoic time; not until half-way through Mesozoic time did the first bird appear, an offshoot, like the mammals, from the reptiles. The bird is no more closely related to the insect than is man.

There were other strange animals in these forests of fern and more is known of their growth. The story is enacted when a tadpole turns into a frog. It begins as a little water-animal, breathing by gills and swishing about by means of a long tail. Then it grows longer and fatter, and faint beginnings of hind legs can be seen. The legs grow and detach from its sides, fore paws appear, the tail shrinks, the tadpole vanishes, and there hops out on dry land, with long legs folded under it, and breathing the air as if it had never known any other life, a frog. That is a rough summary of what happened in the evolution of the frog. Only, of course, no one animal covered the entire development or any considerable part of it. Thousands of years were needed for each



A TITANOTHERIUM, A GIANT HERBIVOROUS ANIMAL FROM THE OLIGOCENE OF NORTH AMERICA

A similar type is found in Mongolia. The picture is based on fossil skeletons in the American Museum of Natural History, New York, and the National Museum Washington, D. C.

From a painting by Charles R. Knight

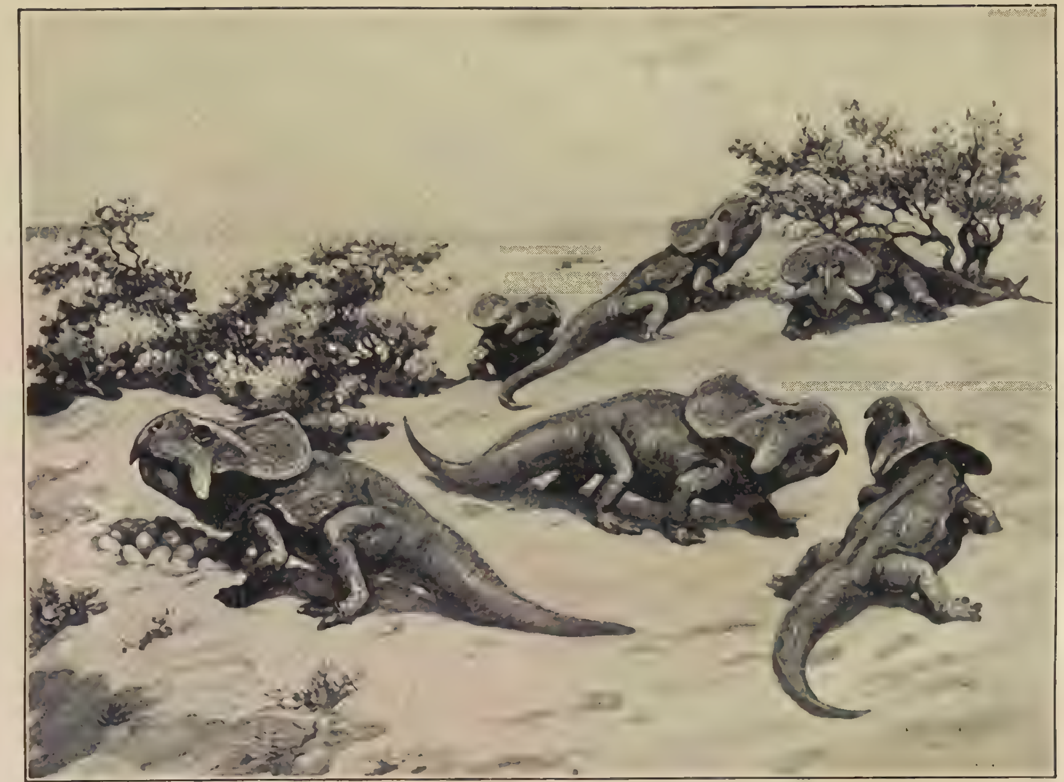
small development. Millions of tadpoles never got beyond the most primitive legs. The modern frog was not achieved until the beginning of Cainozoic time, some 25 million years ago.

The young of every animal go through stages more or less similar to those of the frog. The frog is born from a primitive type of egg and is hatched at an early stage of its development, so it changes rapidly before one's eyes. This particular type of swiftly changing growth is known as metamorphosis. In the case of the mammals, when the young are carried in the mother until fully developed, these early stages are hidden. But they take place with striking uniformity, from the lowest animals to the highest, up to and including man, and the fact forms one of the most interesting confirmations of the theory of evolution.

There were many other amphibia, leading the double life by land and water, in these great forests. Most important were the armored amphibia, squat, enormous-headed creatures, as large as crocodiles, and perhaps rejoicing in a most extraordinary organ, a third eye, situated conveniently on top of the head. (The evidence is not conclusive and is doubted by many scientists.) The reptiles developed out of these same amphibia; and the mammals developed from the reptiles; here is the direct ancestry of man. Now that man has learned to fly, it would be convenient if he had a third eye. But if it ever existed it was not a success and it disappeared with the armored amphibia. A hole in the shell still remains in some living reptiles; and man, along with other mammals, shows in his brain rudimentary traces of this lost apparatus, eye or whatever it may have been, lost 100 million years ago. So indelibly is the record of the past written in every living thing.

In the last millions of Paleozoic years came the first reptiles. There was no sharp break here due to lost links. The land-dwelling reptile grew slowly from the amphibian by clear stages. It was an amphibian who had forsaken the water and had developed accordingly. It was still cold-blooded like the amphibian. It reproduced by laying an egg. But it was a much more highly developed egg of far-reaching significance in later evolution. One is apt to think of these creeping, crawling animals as lowly. In their day they represented a steady sure advance along the line of true progress. In the next era they went astray, crawling down a blind alley, developing into vast, clumsy forms that could not survive the harsh test of changing climate. In these early forms they were clearly the direct ancestors of birds and mammals.

Mesozoic Era. These 50 million years, the Middle Age of the earth's history, form the Age of Reptiles. It saw the rise, the majestic triumph by land and sea and sky, the decline of these strangest of all animals. Theirs was the conspicuous story of the era; a visitor from another planet would have been amazed and appalled by the greatest dinosaurs—some were thirty feet from head to tail—and it would have been impossible for him to conceive that theirs was to be but



© Field Museum of Natural History.

EGG-LAYING DINOSAURS.

From a painting by Charles R. Knight.

a temporary triumph. He might not have noticed at all certain small descendants of earlier reptiles who had developed along a new line and lived inconspicuously among the giants. Yet these were the first mammals, and their descendants were to conquer the earth long after the hugest dinosaurs lay buried in the earth. These first mammals appeared early in Mesozoic time; the first true birds appeared a little later; and about the middle—according to most authorities—came the first flowers.

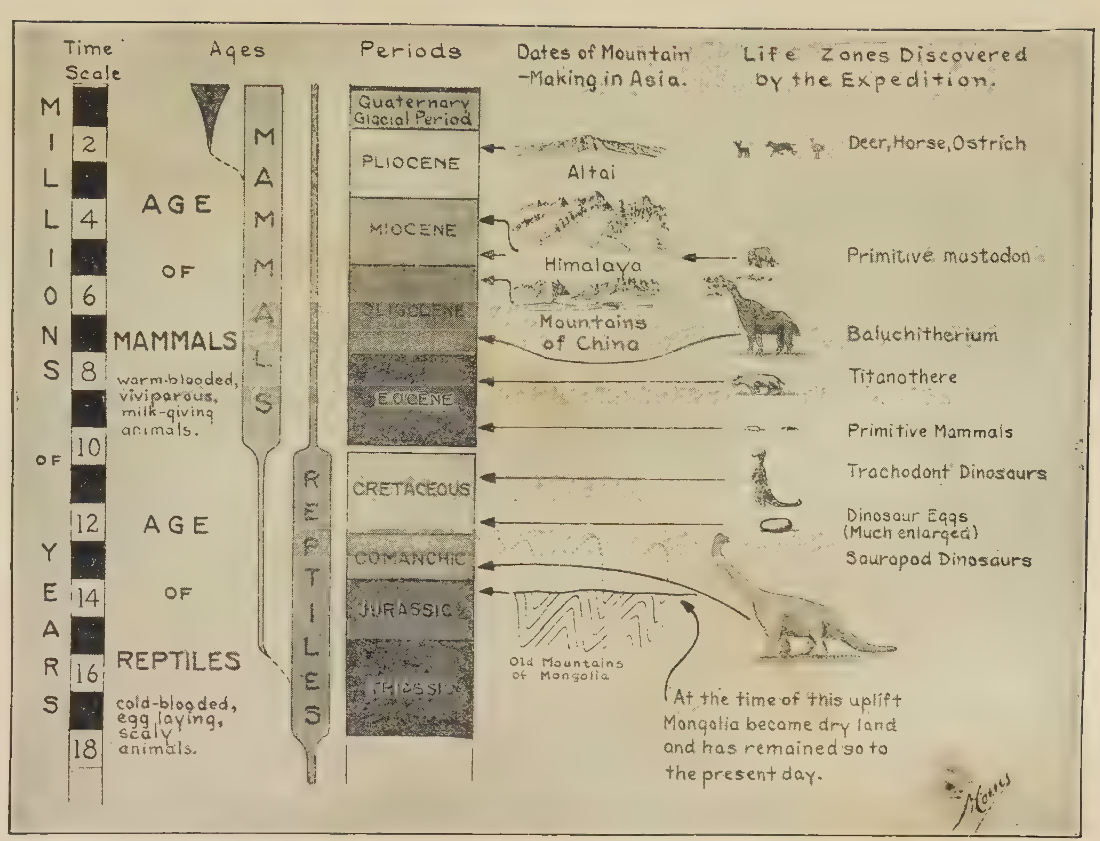
Courtesy American Museum of Natural History.

NEST OF THIRTEEN DINOSAUR EGGS FOUND IN MONGOLIA BY ROY CHAPMAN ANDREWS.

Thus this age, lorded over by the vast bulk of the reptiles, was really important for quite other events. By its end all the great divisions of living things were launched upon the earth. In it the mammal, the bird, and the flower, the three highest forms of life, all inconspicuously came into being. The analogy with human experience is strong. The race is not always to the swift in evolution any more than it is in the practical business of living, nor is the largest necessarily the most important.

What caused the giant reptiles to perish from the face of the earth? The precise geological changes that ended them are not clear. One of the interesting efforts of scientists to-day is to discover cause and effect between the movements in the earth's surface and the great developments in evolution. Some such effects have been traced; the disappearance of the reptiles remains a puzzle. But it is at least easy to see how vulnerable many of them must have been to slight changes in climate. They were huge in size, small of brain, weak in teeth. To thrive many needed a peculiar set of favoring conditions, a huge quantity of grass to eat, flat lands, and shallow waters. These were a good example of what the biologists call overspecialization; fed by easy, favoring conditions over long ages, they grew huger and huger, more and more sluggish, developing no new ability, no new weapon. From one cause or another their ultimate destruction was inevitable.

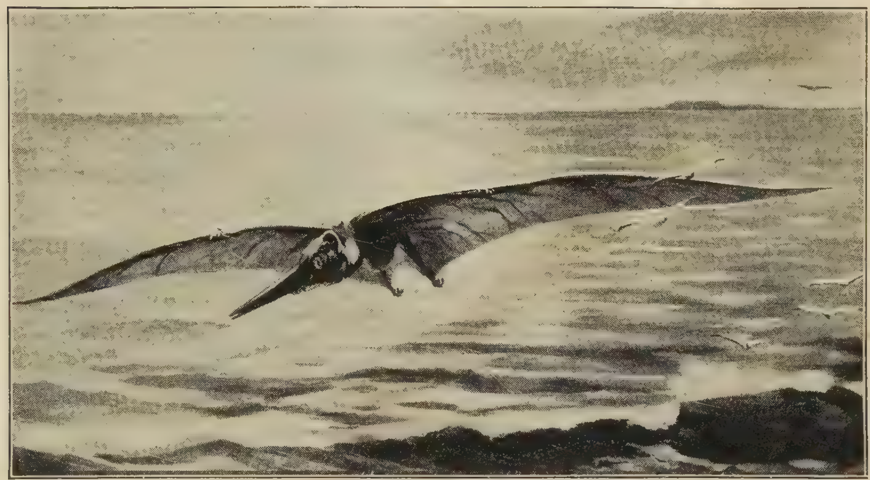
Not all the reptiles were large and sluggish. Many were small and active. There were numerous carnivorous reptiles, some of great size, in addition to the grass-eaters. Some had



From Lucretia Perry Osborn's "The Chain of Life."

CHRONOLOGICAL DIVISIONS OF THE AGES OF REPTILES AND MAMMALS IN EASTERN ASIA. Recent expeditions have made many important discoveries in this region.

fore legs developed into wings and took the air like fabulous bats, twenty-five feet from wing-tip to wing-tip, veritable dragons. These flying reptiles disappeared within the Mesozoic era, leaving no descendants. The modern bat is a mammal just as much as is a flying squirrel. The true bird developed from another line of reptiles altogether. Other reptiles returned to the ocean from which their ancestors had crawled, and with their land limbs modified back into swimming-paddles grew into the terrors of the sea. The famous icthyosaurus (fish-lizard) was one of these. In appearance he resembled the modern porpoise, but the resemblance was wholly superficial, for the porpoise is a mammal gone back to the sea, and this twenty-five-foot tyrant of the oceans was cold-blooded and egg-laying, a true reptile. There was an



Courtesy American Museum of Natural History.

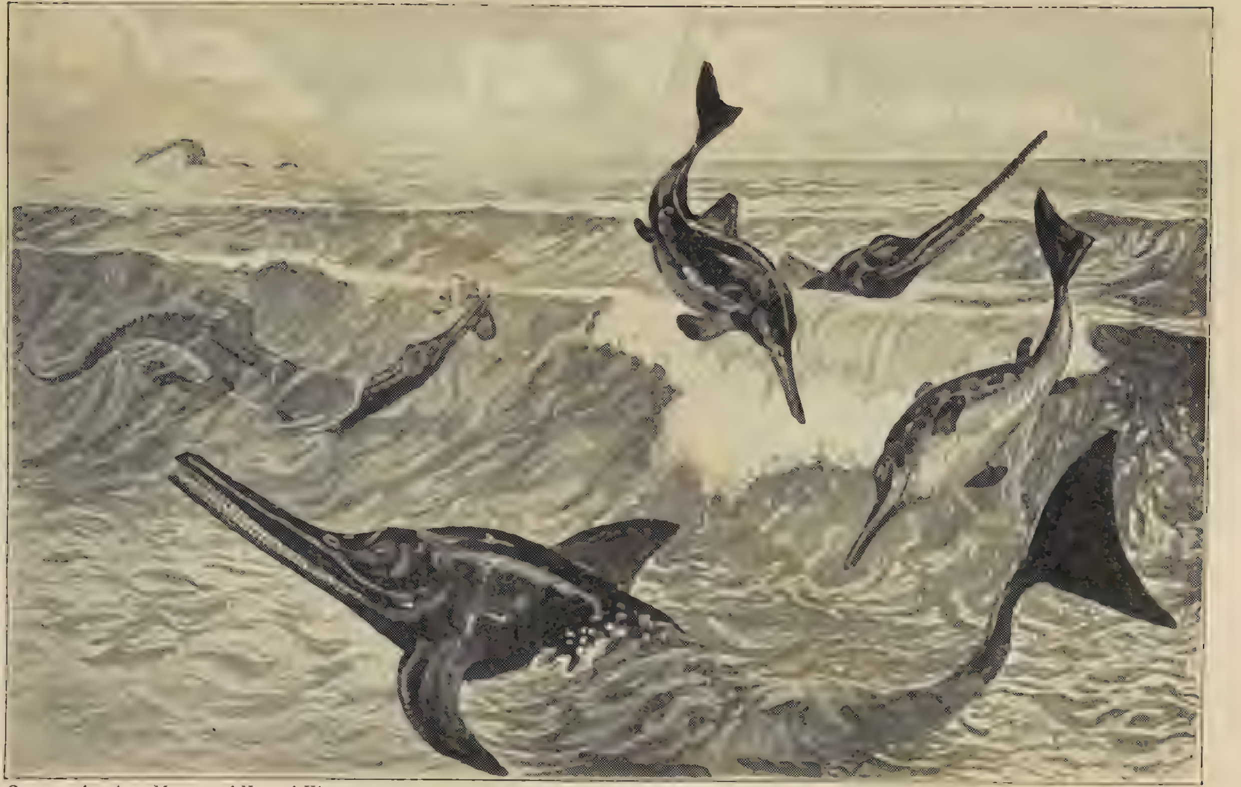
A RECONSTRUCTION OF A FLYING REPTILE, THE PTERANODON, SHOWING THE TREMENDOUS WING-SPREAD.

even more terrifying sea-reptile with a stout body and long snakelike neck, suggesting the mythical sea-serpent.

No wonder this age of reptiles has passed into general knowledge as the strangest era of the past. Look upon Kansas of to-day with its man-made villages and its peaceful man-tilled wheat-fields; and then picture it as it was in the late Mesozoic era when the great inland Coloradoan Sea covered Kansas and all the heart of America. A flock of pterodactyls fly across its shallow sea, like a squadron of aeroplanes. Icthyosauri leap from the water like dolphins; great snakelike heads rear among them. On the shore, low, lumbering reptiles twice as long as an elephant waddle down to drink. Nothing in mythology or fairytales is half as unbelievable as this record of science laid down beyond contradiction in the record of the rocks.

Meantime throughout the bulk of this era there were playing among the eighty-foot dinosaurs of the land the small mammalian reptiles from whom were to descend the line of mammals including man. Their progress was slow; in fact, for millions of years they remained practically stationary. Yet they possessed a power of adaptation, of development, an inherent ability, which was to outlast the bulk of the mighty reptiles.

So in the air and sea as well. The true bird appeared in the air, a descendant of reptiles, but developed along far more efficient lines than the flying reptiles. A skeleton has been found in Germany which is a true bird with distinctly rep-



Courtesy *American Museum of Natural History.*

THE HUGE ICHTHYOSAURS WHO RULED THE SEAS OF THE LATE MESOZOIC ERA.

At the left is another reptile, lizard-like, the plesiosaur.

tilian characteristics. It is the size of a large pigeon, partly covered with feathers, possessing the jaw of a reptile, lined with teeth (which no modern bird has). The earlier steps by which the true bird developed a wing are among the many steps in evolution as yet undiscovered. One theory is that birds and insects alike developed wings from fish fins. If so, science is still left with the problem of flying reptiles and bats upon its hands. Wings remain one of the great unsolved problems of evolution.

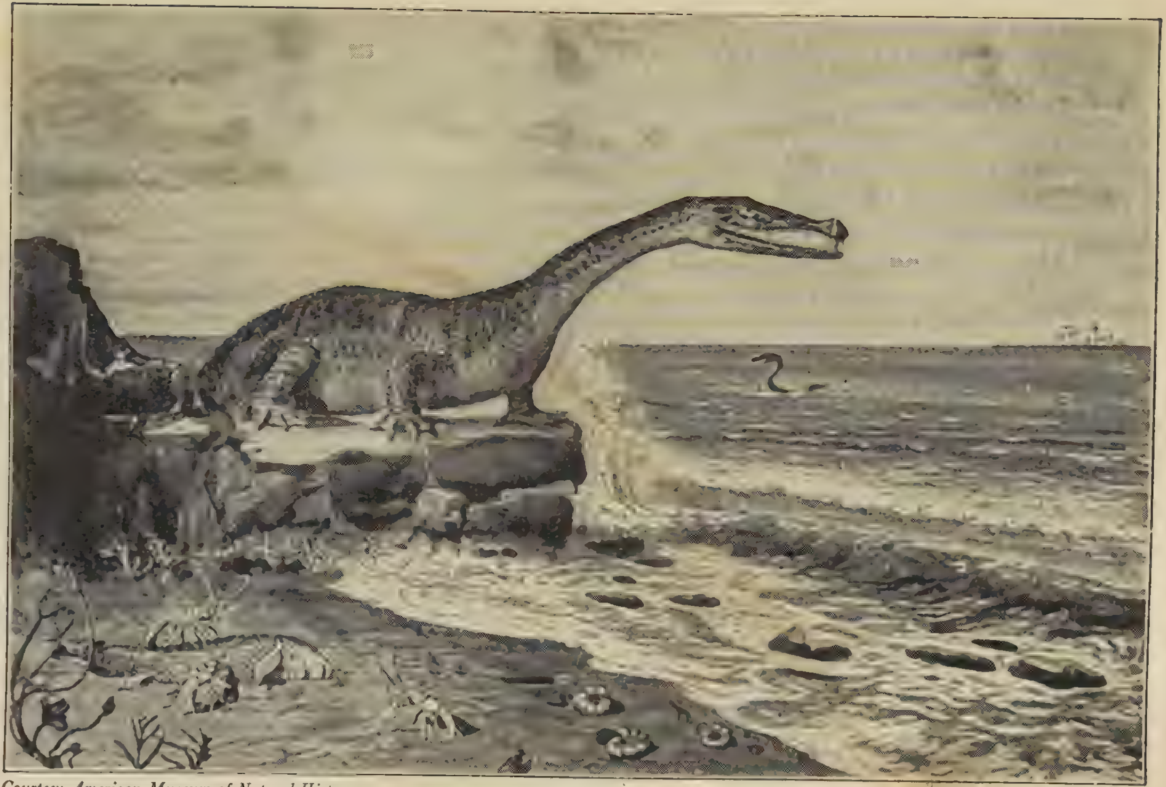
In this closing period of Mesozoic time came also the modern fish. Thus in all three elements, earth, sea, and sky, the future masters were prepared while yet the dynasty of reptiles was at its height.

Cainozoic Era. There were two important evolutionary events in these last 25 or more million years. The first was the rise and triumph of the mammals. The second was the rise and triumph of man, a triumph of which we are part and in which we still live. Either of these achievements may be fairly said to be more wonderful than all that went before. In each case the gap was wider, the improvements more extraordinary, the rate of advance far swifter. It took at least 250 million years to make a jelly-fish, 150 more to make a fish with a back-bone, 50 more to make the great reptiles. It needed but 25 million years more to perfect the mammal; and thereafter but 2,500,000 years to achieve man, a mammal equipped with a brain so far superior to the brain of the highest animal as to rank alone.

Mammals are so called because they nurse their young, and the name singles out a highly important characteristic. For nursing prolongs the period of infancy, and this lengthening period during which parents care for their young is a sure sign of progress among animals as among human races.

But it was by no means the only advance. Warm blood first appeared in the mammal—all other animals are cold-blooded. (Birds have a partial regulation of temperature, which they inherited from the early reptiles.) Most important of all, the brain developed as it had never developed before, in size and in complexity.

No one would have recognized the queer early mammals as ancestors of our modern animals. Yet the line has in many cases been successfully traced down through slow changes of skeletons preserved as fossils. They were very small, these ancestral mammals, for one great difference. Great size comes late in the development of a species, when its triumph is secure and its life relatively easy, as in the case of the reptiles. One can think of the mammals as gradually increasing in size and reaching their greatest height and weight, the climax of their development, about the time primitive man first appeared upon the earth. Since then, within the last 500,000 years, the greatest mammals have slowly declined. Man has been largely responsible for this decline by hunting and killing them and by reducing their wild lands and forests. But this is simply to say that what has happened in the past of evolution when a new and superior



Courtesy American Museum of Natural History.

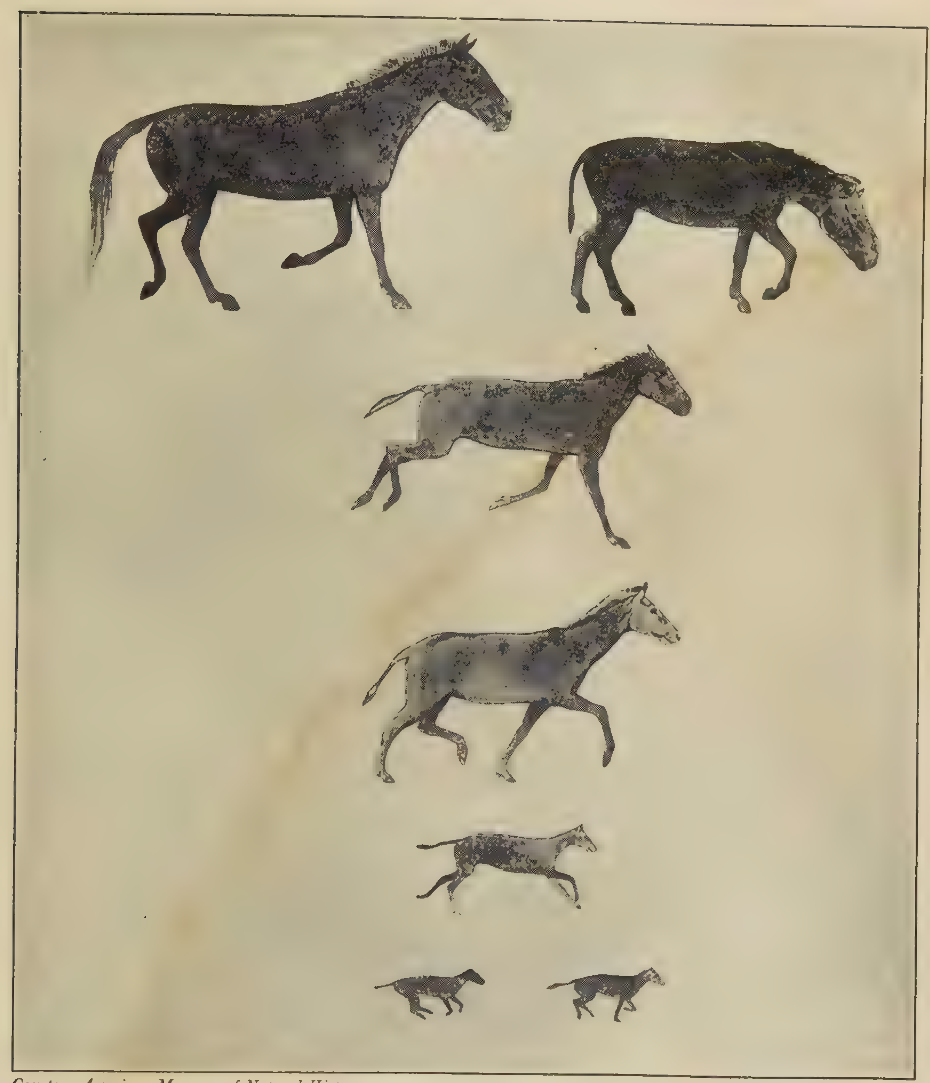
THE NOTHOSAUR, AN AQUATIC REPTILE, A LUNG-FISH, AND VARIOUS CRUSTACEANS OF THE EARLY MESOZOIC ERA.

creature appeared is happening again. The struggle for existence is continuing, and man, the fittest, is surviving in competition with the mammals of huge bulk. The race of mammals reached its first triumph in the primeval forests, and these types are now slowly declining before the latest masters of the earth, men.

Of the small ancestral forms, one of the first to appear was the eohippus (dawn-horse). It stood a foot high at the withers, had a short neck, a long body, and short legs. Many scientists believe that it was the true ancestor of modern horses. These graceful, horselike creatures, about the size of a fox-terrier, swarmed over North America in herds at this period. Somewhat later came the first camel, another North American product. One possible early ancestor was smaller than the modern cat; later camel-like creatures, more certainly in the line of descent, were the size of jackrabbits and later of sheep. Camels reached a modern size and aspect in North America but died out in the Ice Age. Long before this camels had crossed to Asia, and the llamas, of closely allied origin, had crossed to South America.

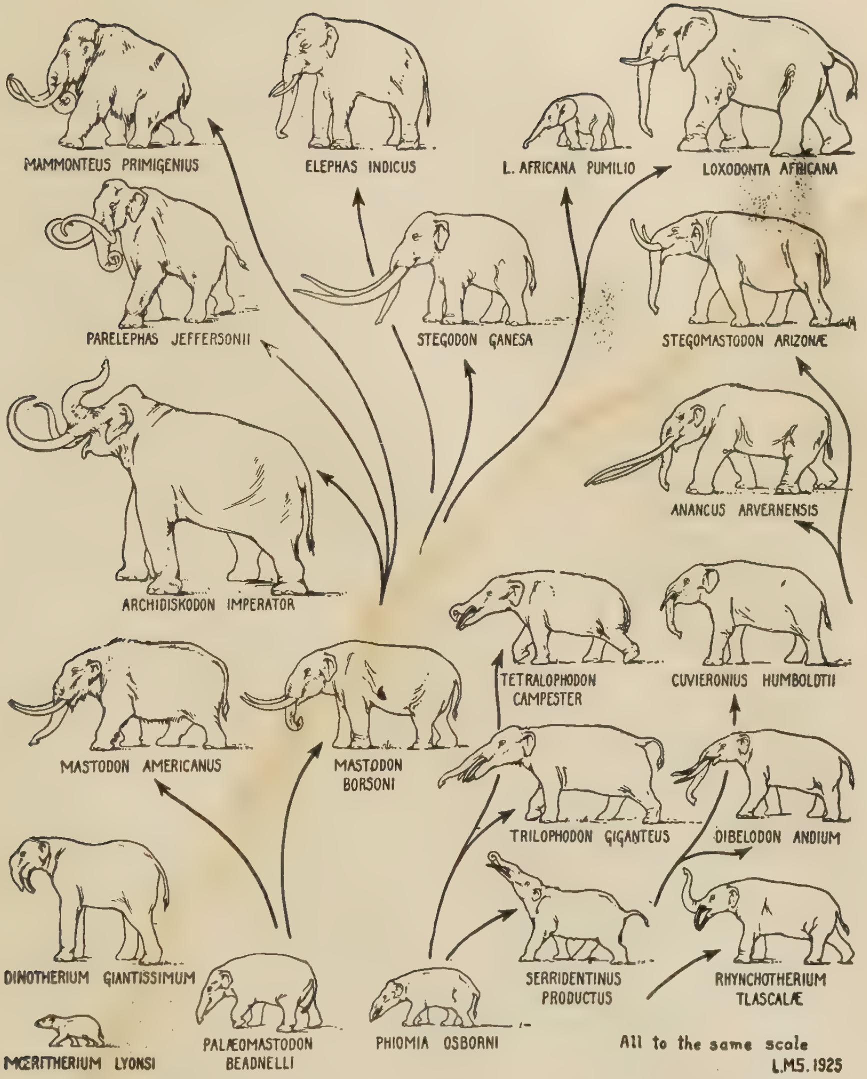
The elephant has been similarly traced from an origin in Egypt where there have been found skeletons of a piglike animal the size of a pony, with a snout distinctly suggesting a trunk. This snout slowly lengthened into a trunk, various species developed in size, and before the Ice Age reached their greatest dimensions, slightly larger than the largest elephants known to-day. These ancestral elephants were confined to Africa until the great uplift which formed the Alps and Himalayas and formed land bridges across the Mediterranean. They then spread rapidly over Europe, into Asia, and thence to America. The mastodon, a near relative of the true elephant, developed early, and died out in Europe before the Ice Age, but continued to roam about North America till recent times; may, indeed, have been hunted down by the Indians, though there is no record or memory of the fact. The mastodon was the one animal with a trunk which made its way to South America. One of the strangest of the early mastodons had four fairly straight tusks with a trunk between.

The most striking and widely distributed elephant of the Ice Age was the famous woolly mammoth of Siberia. These cold-weather elephants stood about nine feet tall at the shoulders (a foot or two shorter than the largest Indian or African elephants of to-day), and had long curving tusks turned upward and inward toward one another. This shaggy monster is one of the few extinct animals which is known to have been hunted by primitive man in Europe; one could not ask for better pictures of the woolly mammoth than those which have been found in the rock caves of France and Spain, drawn at least 25,000 years ago. The woolly mammoth ranged across northern North America at this time, having entered from Siberia by way of Alaska. Wandering as far south as Mexico City were two other larger kinds of elephants, as tall as the largest known to-day.



Courtesy American Museum of Natural History.

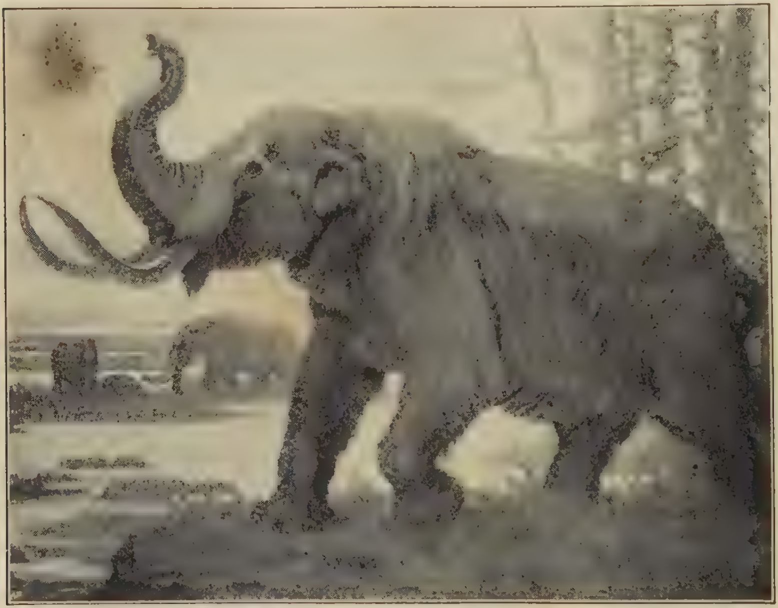
THE EVOLUTION OF THE HORSE, FROM THE LITTLE THREE-TOED EOHIPPUS, NO LARGER THAN A FOX, TO THE MODERN HARD-HOOFED HORSE.


MAMMONTEUS PRIMIGENIUS
ELEPHAS INDICUS
L. AFRICANA PUMILIO
LOXODONTA AFRICANA
PARELEPHAS JEFFERSONII
STEGODON GANESA
STEGOMASTODON ARIZONÆ
ANANCUS ARVERNENSIS
ARCHIDISKODON IMPERATOR
TETRALOPHODON CAMPESTER
CUVIERONIUS HUMBOLDTII
MASTODON AMERICANUS
MASTODON BORSONI
TRILOPHODON GIGANTEUS
DIBELODON ANDIUM
DINOTHERIUM GIANTISSIMUM
SERRIDENTINUS PRODUCTUS
RHYNCHOTHERIUM TLASCALÆ
MŒRITHERIUM LYONSI
PALÆOMASTODON BEADNELLI
PHIOMIA OSBORNI
All to the same scale
L.MS. 1925

Courtesy American Museum of Natural History.

THE EVOLUTION OF THE ELEPHANT FROM AN ANIMAL LIKE A PIG, THE MOETHERIUM.

Throughout the first part of this era South America was an island unconnected with North America, and it developed some of the strangest of mammals. They are all deficient in teeth, the anteater lacking teeth altogether, the sloth and armadillo having none in the front of the jaw. Small degenerate examples have lived down to the present time. In Cainozoic time there were sloths of enormous size, the Megatherium, for example, as large in body as a rhinoceros. When the connection with North America was established toward the end of the Tertiary Age (just before



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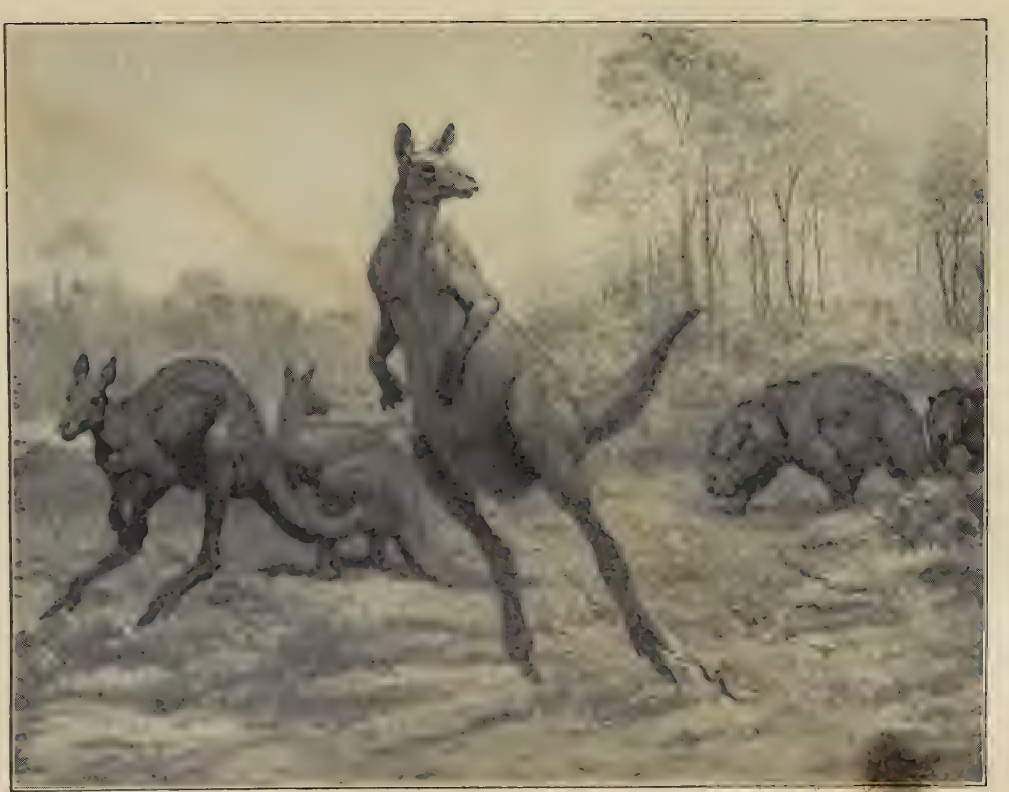
A RESTORATION OF THE MASTODON.

The mastodon, although not quite nine feet in height, is nearly twice as broad as an elephant. It may have been a contemporary of early man at the end of the glacial period in North America.

From a painting by Charles R. Knight.



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A RESTORATION OF THE GIANT KANGAROOS AND WOMBATS.

From a painting by Charles R. Knight.

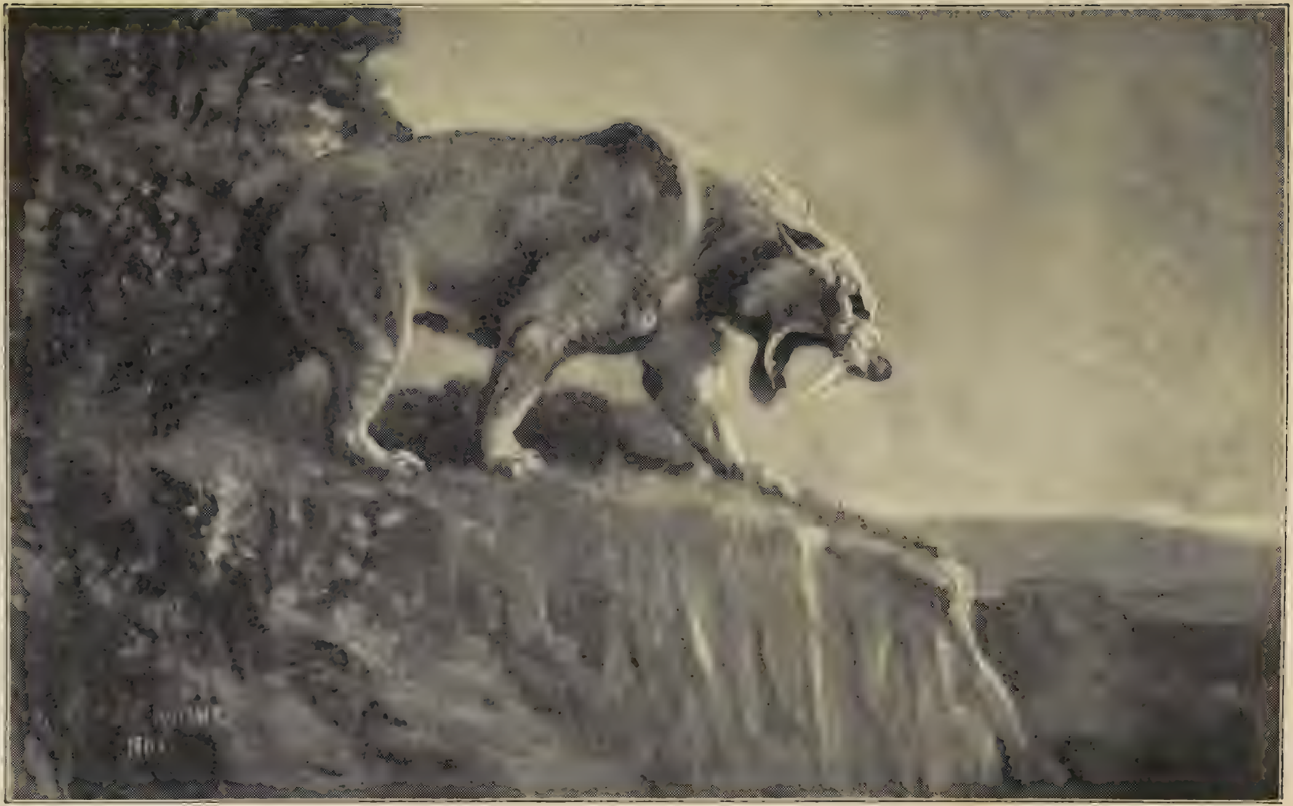
the first glaciation), these sloths wandered north as far as Virginia. There the fossil claw of one was discovered by Thomas Jefferson, but at that time no one suspected the existence of giant sloths, and the claw was thought to be the claw of a great lion.

Long before the first Ice Age the list of mammals was practically complete. The ruminants—sheep, oxen, deer, bison, etc.—had all developed in Asia and Europe from a common stock; most of them did not, however, make their way into America till the Ice Age, and sheep and oxen did not reach America till brought by man in modern times. Of the carnivora, the primitive ancestors of the dog family had developed into such highly specialized and widely different forms as the wolf, the fox, and the bear; and the cat family had developed types akin to our modern lions, leopards, and tigers, and also another variety of tiger, the sabre-tooth tiger, with long, sharp, tusklike teeth. This famous beast was probably the most terrible beast of prey the earth has ever seen. It is not too much to say that it ruled the northern hemisphere for many thousands of years. For some unknown reason the sabre-toothed tiger began to decline in Europe toward the end of the Tertiary Age, and was on its way to extinction when the first ice-floes descended from the north. It lived on in America till long after.

Two other groups of mammals should be mentioned. One comprised those land vertebrates which reverted to the water, the whale and the seal, for example. As has already been noted, the whale carries concealed under his skin the remnants of the hind legs which his reptilian ancestor went to much trouble to develop. Safely back in the sea, the whale developed in size much as did the giant reptiles on the land, even exceeding them in size. There has never been any other animal as large as the great whales of modern times.

The other group is known by the geologists as the primates. They include in it the small lemurs, the monkeys, the great apes, and man. Unfortunately, the fossil ancestry of the primates is still largely lacking. As might be expected, more remains of the ancestry of the numerous monkey clans have been found than of man. Skeletons dating from about the middle of the Tertiary Age have been dug up in Egypt and in the Siwalik hills of India which may possibly be the common ancestor of gibbon, chimpanzee, gorilla, and orang. The line of man's ancestors has been traced back only to the beginning of the Quaternary Age; that is, through the Ice Age. The primitive savage ancestors then living were already men, far removed from the highest known ape. Beyond them lies a stretch of hundreds of thousands of years before the common ancestor of man and ape is reached.

Because of a general resemblance in skeleton between ape and man, it is the hypothesis of scientists that these apes and man had, at some remote period in Cainozoic time, a common ancestor—just as the bear and the wolf, or the antelope and the bison, had a common ancestor. But how near or far in Cainozoic time, and what the type of this common an-



Courtesy American Museum of Natural History.

RESTORATION OF THE SABRE-TOOTHED TIGER.

From a painting by Charles R. Knight.

cestor, are wholly unsolved problems. Much has been said and written of a "missing link" between monkey and man. It can be seen that this is far from an accurate way of stating the truth. To begin with, there is no possibility of a direct link with the modern apes; man is not descended from any monkey of to-day. The relationship that scientists are using as an hypothesis for research conceives of a common ancestor perhaps a million years ago, neither ape nor man, nor necessarily closely resembling either. This ancestor may have been a primitive tree animal or a primitive ground animal. The prevailing theory has been that he lived in the trees and that thereby man's ancestor first learned to walk erect, and thus released his fore paws so that they could become hands, undoubtedly the greatest step in the evolution of man. At some early point in this view, man must have descended from the trees and taken up life upon the ground. But some scientists lean toward the view that man's ancestors were always ground apes. Nor should it be forgotten that there is a chance, improbable but possible, that the present resemblance of man to ape is only the result of a parallel development and that there was no common ancestor till one gets back to the common ancestors of all the mammals. Here, as so often, there is need to understand clearly what scientists know and what they assume as a basis for investigation and research. Not one "link" but a whole vast chain of links is missing, and it is wholly impossible as yet to say what the earlier links in the chain resembled. The record of fossils is constantly presenting such gaps, often far larger. This gap is of peculiar interest to man, and he may hope that researches now going on in the highlands of Asia may some day identify these missing forebears.

CHAPTER VI

THE COMING OF MAN

Thus man came by his body and his brain, thus by every cell and portion of his body is he linked with the past, is the child of worm and fish and reptile and primitive suckling mammal. It remains to be seen how man took this inheritance and made of it a new thing. In the first discovery of evolution and man's kinship with living things there was occasion for stressing this relationship with tree and bush and the animals of sea and field and sky. Enough years have now gone by to permit a level look at the past and judge the steps in the ascent without prejudice. One can watch the mystery of life begin; one can picture the division of life into vegetable and animal; one can note each considerable achievement of organism thereafter. What shall be said of man's achievement in comparison with these other steps? Nothing less than that it deserves unmistakably to rank with the greatest. With man, mind becomes a thing as new and marvellous as was the first birth of living matter in dim Archean years. Life is born afresh on a new plane.

The face of the earth was changed then. The face of the earth is changed now. The mind of man has hewn away forests and harvested the plains. It has upraised cities and severed continents. It has mastered the sea with ships and by wires, and without wires brought the whole earth within earshot. Here is an evolution as strange and unfathomable in the present terms of science as that birth of living matter a hundred million years ago. In some hour of supreme wisdom, far distant, science may explain the facts of consciousness and reason as it may explain the facts of life, as it has already defined gravitation and the rule of three. But that hour is not yet and, in the meantime, one must accept and describe this marvellous age for what it appears, without pretending to understand its essence.

The Psychozoic Era some geologists have suggested calling this new era, which is to name it the Era of the Mind. Its roots are in the past. For thousands of years its growth is slow, almost as slow as the evolution of any new organ of the body, of leg or wing. Then swiftly and more swiftly comes the light. History is the stage whereon one sees the mind of man grope through dark and dubious centuries into the sudden dawn of modern times.

I. THE EVIDENCE OF EARLY MAN

Any one who has picked up an Indian arrow-head in a field knows the general method by which knowledge of ancient man has been gained. By fingering this piece of carefully chipped flint, one comes closer to that ancient hunter who there drew his bow and let fly an arrow than from reading many books. At once he stands forth a real being of

From a photograph by Ewing Galloway.

SCENE AT THE EXCAVATIONS IN THE PECOS VALLEY, NEW MEXICO, WHERE SKELETONS, POTTERY, PRIMITIVE WEAPONS, AND OTHER RELICS OF AN ANCIENT INDIAN CIVILIZATION HAVE BEEN DISCOVERED BY DR. ALFRED KIDDER.

whose skill and customs one can guess much. Just as the hard parts of the first shell-fish are the first traces of animal life preserved to us from Paleozoic time, so now these hard parts of man's earliest civilization, his arrow-heads, his spear-heads, his tools, later his pottery and pictures on stones, give the first news of man. Here, too, actual skeletons have come down, precious beyond all else for what they reveal of ancient man's body. But such bones are rare, for only under most exceptional conditions have they escaped decomposition.

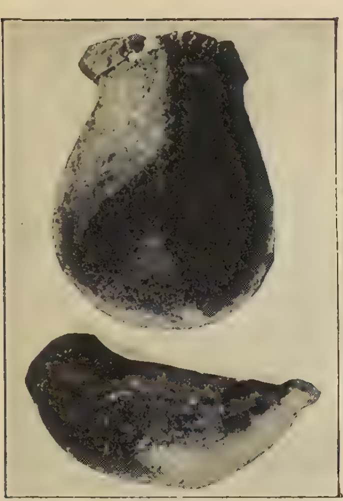
History begins when man first left written records of himself which have been preserved. That was only 3,000 or 4,000 years B. C., some 5,000 or 6,000 years ago. The story of the earlier period is called prehistory and the period is called prehistoric. This division is still important in so far as it points to the invention of writing, one of the capital discoveries of man. It was formerly also highly important because it marked the beginning of all knowledge of ancient man. This distinction has faded away as the past before writing, man's unwritten history, has been slowly but steadily reconstructed by archæologists. The dates of the early Egyptian dynasties carved in rock do not tell as much as the skeletons and weapons and tools buried beneath the floor of an ancient cave in southern France, all dating from a period long before writing was invented. The great difference is exactly with respect to the matter of dates. In historic times the order of events and the length of time elapsed is generally clear. In prehistoric times one enters a different realm. Thanks to the labor of archæologists, the life of these early men has become amazingly definite; one can know, in many cases, how they lived, what they ate, to the fraction of an inch their height, their length of bones, the capacity of their skulls. The year when these men lived is unknowable; it is not even a given century or a certain thousand of years. The most important events in the development of these early men cannot be fixed within tens of thousands of years. The archæologist finds a skeleton in a certain stratum of rocks. The geologist can tell him what was happening then to the face of the earth; he can tell him what came before and what followed after. He can, by measuring the thickness of the stratum, give a rough estimate in tens of thousand years of the time which it took for the stratum to be laid down by rain and weather. That is the most he can do. In excavating the floor of a cave, the archæologist faces a like problem; here the matter deposited is chiefly the work of man, skeletons, tools, the remnants of meals, the slow dust of time. Here also rough estimates are the best one can expect.

Take, for instance, the important question of the total length of the glacial periods: that is to say, of all Quaternary time. The figure of 500,000 years has been mentioned as a rough estimate. In fact, the estimates of the geologists range all the way from 100,000 years to 1,000,000 years. It simplifies proportions to use definite figures, but it must be clearly understood that 500,000 is simply a rough average of the many estimates and possesses no pretense to accuracy or finality.

The farther back the record of man is traced the hazier becomes the picture, the more limited the evidence. A point is finally reached at which the existence of weapons and tools fades into doubt, and for actual human bones there are only the remnants of three skulls, one from Java, one from Germany, one from England, all much debated, upon which to base a reconstruction of such men as then lived. Digging for remains of early man is going on constantly, in India, and elsewhere, wherever the hypotheses of the archæologists suggest the likelihood of discovery. At any moment there may appear fresh facts as to these first men. But at the present time little can be taken as certainty in these early years, and the hour which holds the greatest interest is that in which the picture first becomes definite and undebatable—when the stone weapons clearly chipped by human hands are found in quantity and enough skulls and bones are in existence to present the men to us clearly. That is with the arrival of Neanderthal man, thus named from the cave near Düsseldorf, in Germany, where the first skeletons of this type were found. That important event has been dated by the geologists as having taken place in one of the warm periods between glaciers. But, as has been noted, there is much doubt as to how many advances and retreats of the glaciers took place, and there is some doubt as to exactly which warm interval saw the development of the Neanderthal man. Going back to the question of years, the best one can say of this clear arrival of man is that it took place not less than 50,000 years nor more than 200,000 years ago; and that accepting for convenience the figure of 500,000 years as the total length of the Ice Age, these men first began to chip stone weapons in Europe more than 100,000 years ago. (A far earlier date would be urged by some scientists.)

Thousands of these stone tools and weapons have now been discovered and studied and classified in Europe, and the archæologists have based upon them an accurate and fairly detailed history of the development of these early men. In the deeper strata the stone weapons are the roughest sort of rocks, chipped a little on one end to give a sharper edge, and that is all. They improve until at the end, just before the discovery of bronze, these early men of Europe were chipping and polishing spear-heads and axes as beautifully proportioned and finished as any modern tool of steel.

For by far the greater part of the Stone Age, primitive man never thought of polishing his stone tools. He chipped them, flaked them more and more expertly, but never attempted what seems the obvious and easy job of smoothing their surfaces. For some 100,000 years (by the rough estimate) he waited to make this simple invention. There could not be better proof of how slowly and painfully the first gains were won. Thereafter, the pace steadily quickened. Man—the most advanced man, that is—remained in the age



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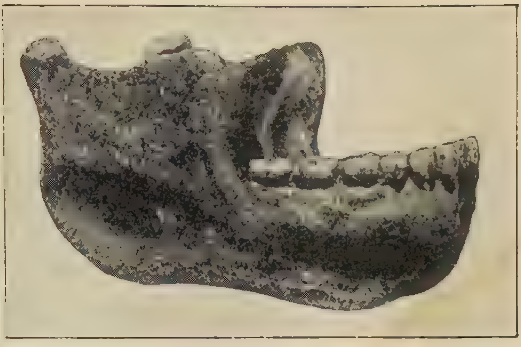

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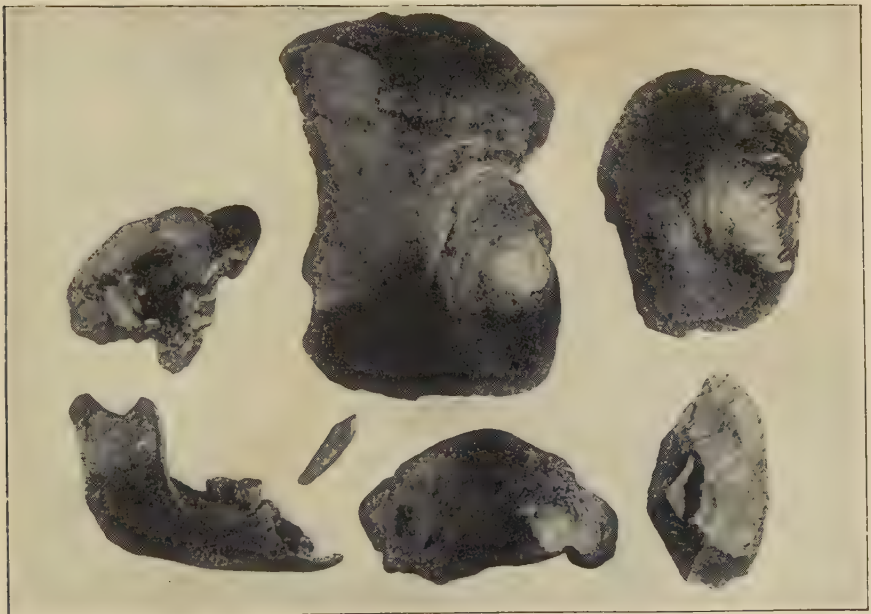


Courtesy American Museum of Natural History.

C

A. TOP AND SIDE VIEWS OF THE SKULL OF THE JAVA APE MAN, *PITHECANTHROPUS ERECTUS*, THOUGHT TO BE AT LEAST 500,000 YEARS OLD.

B. THE HEIDELBERG JAW WAS FOUND IN A SAND-PIT NEAR MAUER, GERMANY, IN 1907.

The retreating ape-like chin shows its primitive character.

C. FRAGMENTS OF THE SKULL OF PILTDOWN MAN, FOUND IN ENGLAND IN 1912.

Piltdown man was nearly contemporary with *Pithecanthropus.*

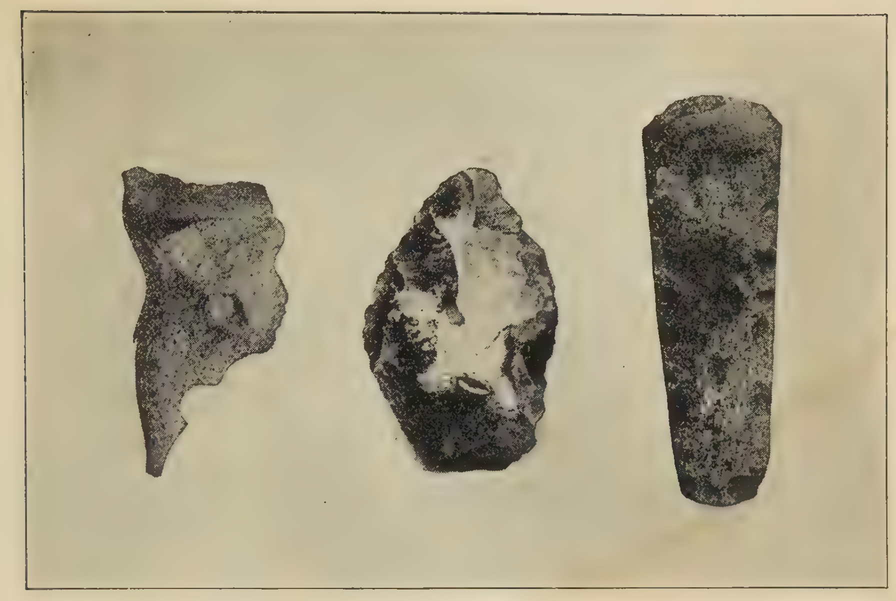
of polished stone tools for less than 10,000 years (perhaps as little as 5,000 or 6,000 years); he discovered bronze, used it for 1,000 to 1,500 years, and then made the greatest discovery of all, iron, by which the modern world has been built. Roughly speaking, man began to leave written records about the time of the discovery of bronze; therefore the Bronze Age marks the beginning of historic times. It lasted from 4000 to 1500 B. C. in Asia, and from 2000 to 1000 B. C. in Europe. (The Bronze Age and Iron Age overlapped. There is evidence of iron in Babylonia as early as 3000 B. C.)

The archæologists divide the Stone Age into two periods: the Old Stone Age of chipped tools and the New Stone Age of polished tools. For these, the names of Paleolithic Age and Neolithic Age, of Greek derivation and meaning the same as the English phrases, are often used.

This arrangement of prehistory about great inventions has been more or less compelled by the fact that it is the remains of these inventions, arms and tools, which yield most of our knowledge of these periods. There is considerable logic, also, in dividing the record of man into these periods. The history of man is largely a history of great inventions. They are closely akin to the development of legs or wings or other organs in the evolution of living things. Man has, for a good illustration, developed wings of his own in the last generation, which must, in the long run, have a great effect upon his outlook and way of living.

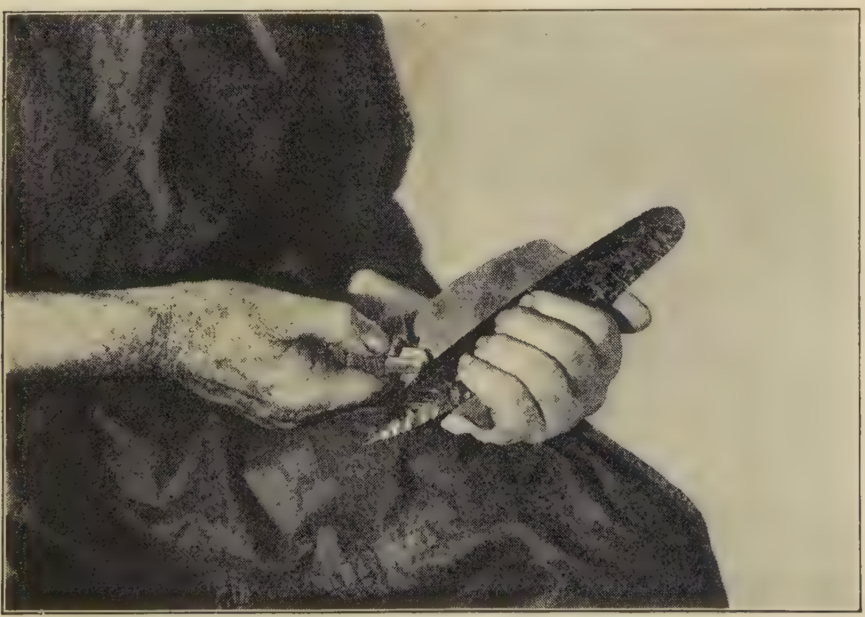
Nevertheless, inventions are not the whole story. These same Old Stone Age men, who never learned to polish their tools, reached a state of civilization of real worth. Side by side with this primitive state of tool-making there flowered a beautiful and clear-seeing art, a respect for the dead and thought of life after death. The Greeks reached a freedom of mind and a beauty of expression in all the arts which have never been surpassed, and that without telephone or telegraph or railroads or printing-presses. They had no more to work with than has the most backward peasant of Europe —the simple hand processes of weaving, the making of pottery, stone-cutting, and the forging of iron. (The Greeks of history coincide with the rise of the Iron Age in Europe.) Plainly there is much more to life than inventions in the modern sense of the word.

Of the great inventions of man, using the word in its broadest sense, several of the most important were achieved even before the Old Stone Age. The family and the hunting-pack undoubtedly came to man from the dim past of animal life; both of these groups and loyalty to them were already warm in the hearts of man before he began even to chip stone weapons. The use of his hands may fairly be classed as the first great invention of man; in fact, it may be considered that all he has done since is to add new tools from the outside world to these parts of his body, his first tools. Fire and speech are the other two great inventions that followed. With this early equipment should also be classed some belief



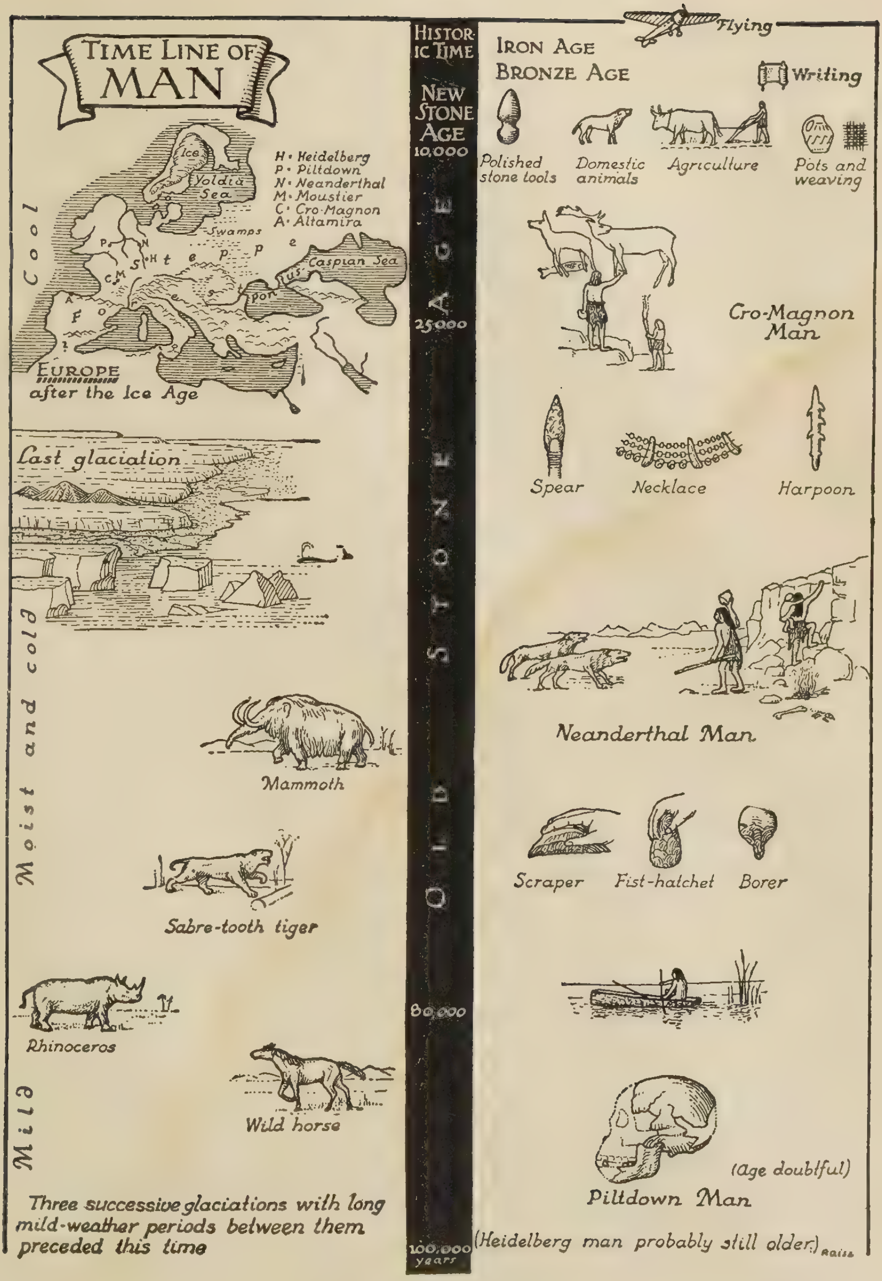
THREE GREAT TYPES OF FLINT IMPLEMENTS.

Left to right: Eolith, a flint shaped accidentally. A paleolith used by Neanderthal man, partly fashioned. A Neolithic axe-head, partly polished.



Courtesy American Museum of Natural History.

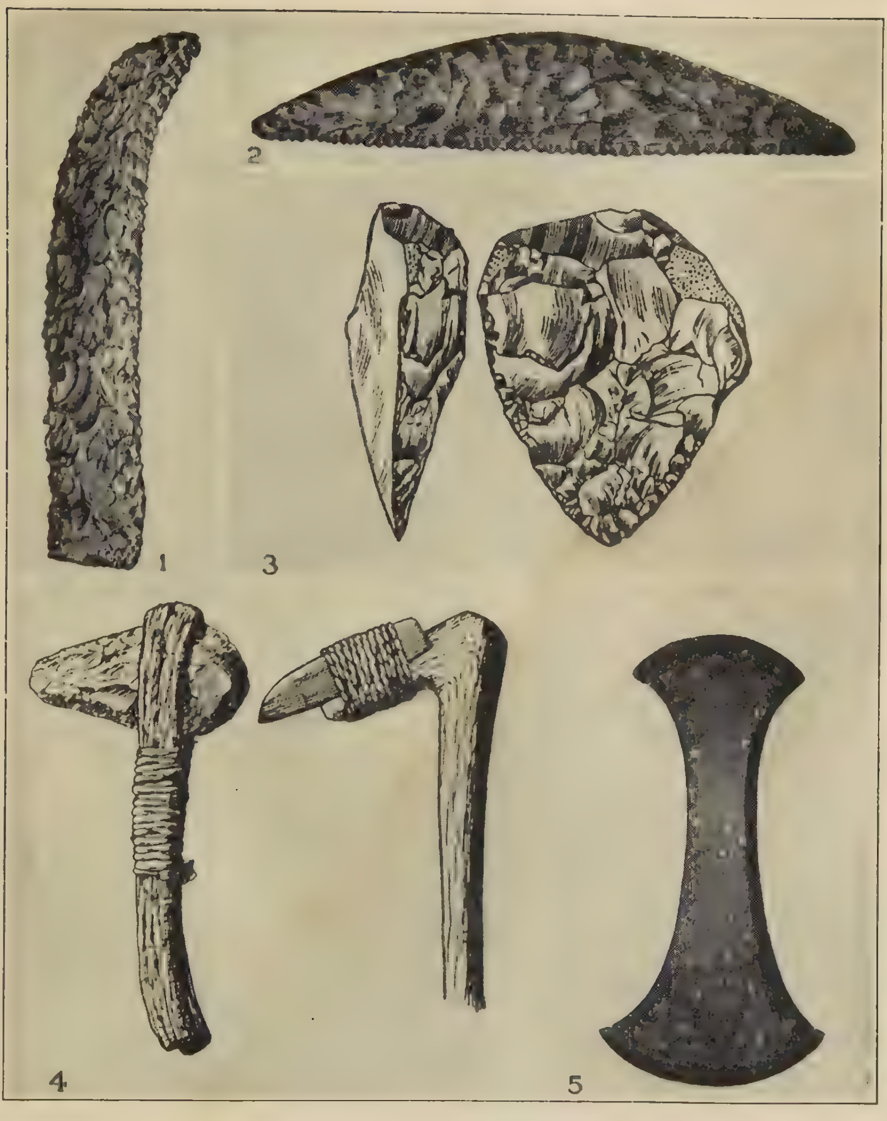
THE FINER CHIPPED FLINTS WERE MADE BY PRESSURE WITH A BONE OR WOODEN IMPLEMENT.


TIME LINE OF MAN
HISTORIC TIME
NEW STONE AGE
OLD STONE AGE
10,000
25,000
80,000
100,000 years
Iron Age
Bronze Age
Flying
Writing
Polished stone tools
Domestic animals
Agriculture
Pots and weaving
Cro-Magnon Man
Spear
Necklace
Harpoon
Neanderthal Man
Scraper
Fist-hatchet
Borer
(Age doubtful)
Piltdown Man
(Heidelberg man probably still older.)
Raisz
H · Heidelberg
P · Piltdown
N · Neanderthal
M · Moustier
C · Cro-Magnon
A · Altamira
Ice
Yoldia Sea
Swamps
Steppe
Caspian Sea
Pontus
Europe after the Ice Age
Cool
Moist and cold
Mild
Last glaciation
Mammoth
Sabre-tooth tiger
Rhinoceros
Wild horse
Three successive glaciations with long mild-weather periods between them preceded this time

that seems a forerunner of religion, for the earliest complete skeletons of paleolithic men that have come down to us show by their manner of burial that there then existed some thought of a life after death. These first stone-using men had therefore already gained much. From the modern point of view which lays stress on bathtubs and fast railroad-trains, they had little; but they had most of the essentials of the highest civilization. Parents loved their children and cared for them, there were groups or communities to which every one owed loyalty, there was fire to cook meat and make caves warm, there was talk, there was thought of something beyond the natural world. Man has done wonders since with this raw material of civilization. He has added but little to its list of essentials.

2. THE LOST AGES

One cannot help feeling intensely curious about that great gap in the history of man which stretches from the age of the primitive mammals at the beginning of Cainozoic time, some 5 million years ago, down to that relatively late hour perhaps 100,000 years ago, when the first certain proof of his presence begins. When a clear trail is picked up in the Old Stone Age, it is clearly man far along on the road of development. Fifty thousand years ago there were brains as large as brains of to-day. There were probably beings who were unmistakably human on the earth at the dawn of the glacial period, 500,000 or more years ago. The trail may be



TOOLS OF THE STONE AGE MAN.

Paleolithic tools: 1, curved knife; 2, saw; 3, hand axe, or coup de poing; 4, axes showing methods of attachment to handles.
Neolithic tool: 5, axe-head of polished stone.

found even farther back. There was no sudden arrival of man in any case; one must picture a long period of time, tens of thousands of years, in which it would have been impossible to say whether these ancestors of ours were men or not.

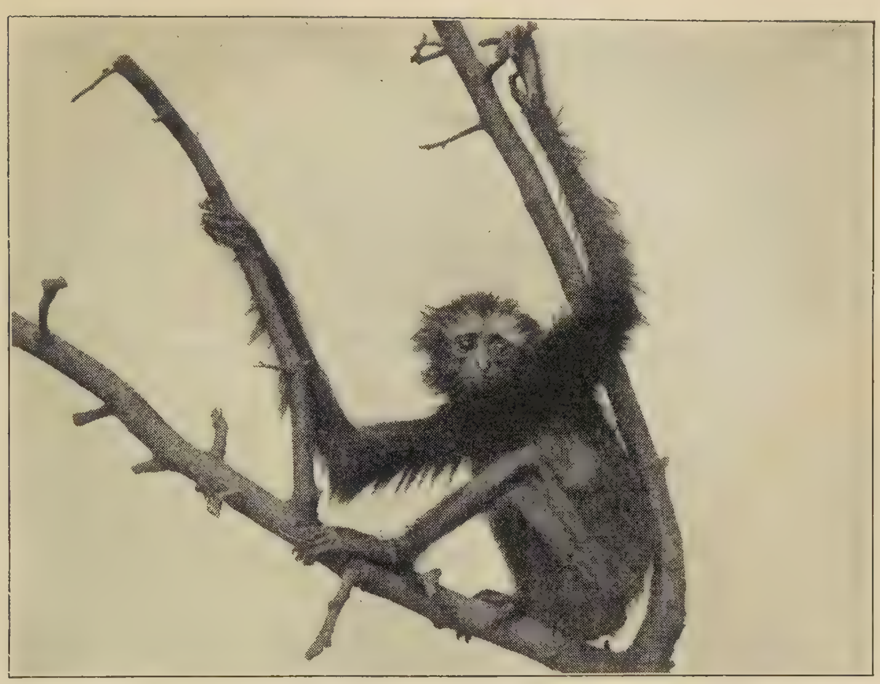
As to the place of man's birth, modern scientific thought has tended to converge upon central Asia. Earlier guesses suggested Africa, and there are still many scientists who hold to the African hypothesis. But the discovery that most modern mammals developed in Asia and that the most primitive skeletons of apes have been found there has brought forward the hypothesis of central Asia as the cradle of man. It is only an hypothesis, however. Africa has been very inadequately explored. So have Asia and the Malayan Archipelago. There is the additional possibility that man developed on a lost continent, perhaps on that Gondwana Land, for example, which geologists believe united Africa and India until Cainozoic time.

Purely as an hypothesis, to show the present direction of scientific research, and to make these remote ancestors more real, here is a picture not of how man did come but of how he may have come.

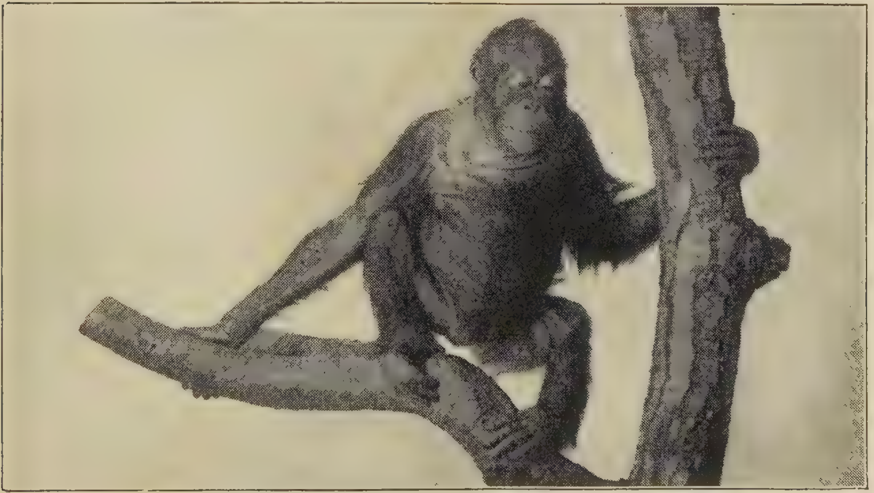
If, then, man did first appear in central Asia, it was very possibly about the middle of Cainozoic time that he first became a separate species. It was then that the great trough of the ancient Mediterranean began to rise, and, first in the west, then running eastward, the great folds of the Alps and the Himalayas were thrust skyward. These colossal changes in the surface of Europe and Asia meant great changes of climate. The lands were higher and wider, the air dryer and cooler. Forests gave way to plains. The development of the grazing animals dates from this time. It was a typical period of change and trial, of severe, enduring test for existing species, when natural selection was weeding out the unfit at a quickened pace.

Upon certain small hairy animals, mostly tree-dwellers, some perhaps living on the ground, the test was especially hard. Their home was slowly disappearing about them, and with it their chief protection from sabre-toothed tigers and the other great carnivora who thrived in this period. The weather, too, grew colder. The old tropical warmth and comfort and safety for tree-dwellers were slipping away. A new world was at hand, for which most of them were ill-fitted and unprepared.

If, as the prevailing hypothesis of scientists has held, man's ancestors once lived in the trees, the important event of the descent to the ground may have taken place at this time. If the tree-apes were a separate stock, his ancestors were already on the earth, and their task was one of adaptation to cold and opener country. In either case the tree-apes who could not face the new life drifted southward by their familiar tree-road clinging to their warm and safer homes, retreating before the threat of cold and danger. In each direction were different climates and ways of life, and in each direction there slowly developed the different varieties of



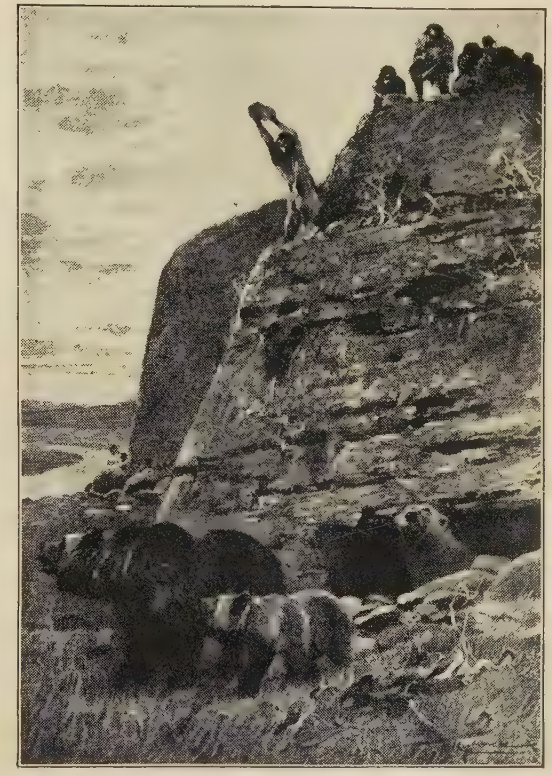
THE GIBBON IS THE MOST PRIMITIVE OF THE ANTHROPOID APES AND IS ESPECIALLY ADAPTED TO ARBOREAL LIFE.



Courtesy New York Zoological Park.

THE ORANG-UTAN, WHILE A TREE-DWELLER, IS LESS EXTREMELY SPECIALIZED THAN THE GIBBON.

apes. The ancestors of the chimpanzee and gorilla wandered to the southwest and settled in Africa; the gibbon developed in India, the Malay Peninsula, and the islands beyond, then attached to the mainland; the orang grew to his giant size in what are now Sumatra and Borneo. Certain other apes spread westward into Europe, but the climate was not favorable and they died out there with the coming of the Great Ice Age.



HUNTING THE CAVE BEAR IN PALEOLITHIC TIMES.

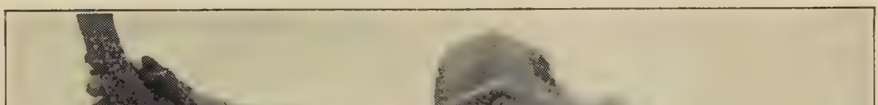
From a painting by W. Kuhnert.

Man, or the ancestor of man, remained to do battle with the new world. Why did he remain? How was it that instead of succumbing to the strain of cold and new perils, he succeeded in adapting himself to his new life and grew in sense and skill so that unarmed by tusk or claw and unprotected by shell or hide he survived to become master of the mightiest beasts of prey? Science has no answer and here is the same old riddle. Why does one boy struggle upward and become Abraham Lincoln and another not? Why has one nation survived while others passed away? Why did the first amphibian crawl out upon the dry land, the first fish grow a back-bone, the first creature like the amœba learn to pull himself around, the first living matter begin to live? It is all one story and all one mystery—the mystery of life. Science has made enormous progress in discovering the laws which govern growth. Why living things grow, why, age after age, they thrust up and up and struggle on and on, till some few are enabled to hold the ground won and prepare for a fresh charge, is still hidden.

It was formerly thought by some scientists that man must have had a diverse origin, that the negro and the Chinaman and the European could have had no common ancestor who was human, that each was descended from a different type of apelike ancestor. But a closer study of anatomy has tended to unite scientific opinion on the contrary view. One is therefore justified in considering it probable that every man upon the earth to-day is descended from this single stock of manlike forebears produced by this struggle with fate, perhaps on the highlands of central Asia. Their differences of color and appearance have developed exactly as have developed the several kinds of apes, or the different varieties of any animal, through the effect of climate and manner of living slowly, invisibly altering skin and feature through the ages.

The first dispersal of man's ancestors took place many tens of thousands of years ago, probably long before the record

THE CHIMPANZEE HAS THE PROMINENT RIDGES ABOVE THE EYES WHICH ARE PRESERVED IN NEANDERTHAL MAN.

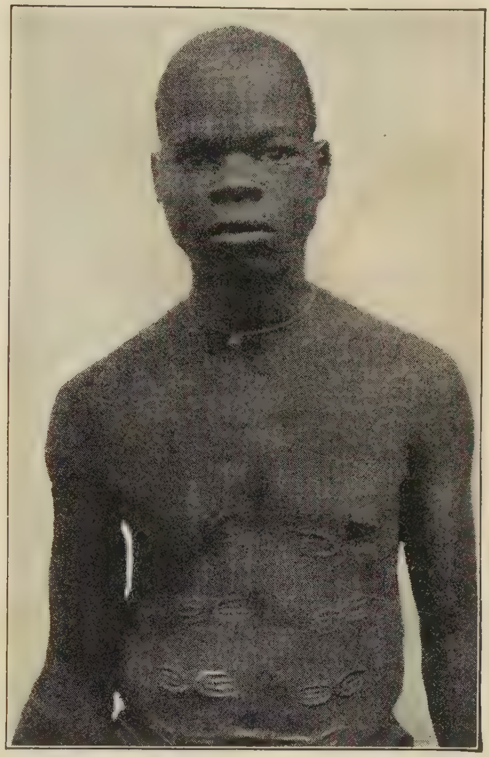


Courtesy New York Zoological Park.

THE GORILLA IS THE LARGEST AND MOST HIGHLY DEVELOPED OF THE ANTHROPOID APES.

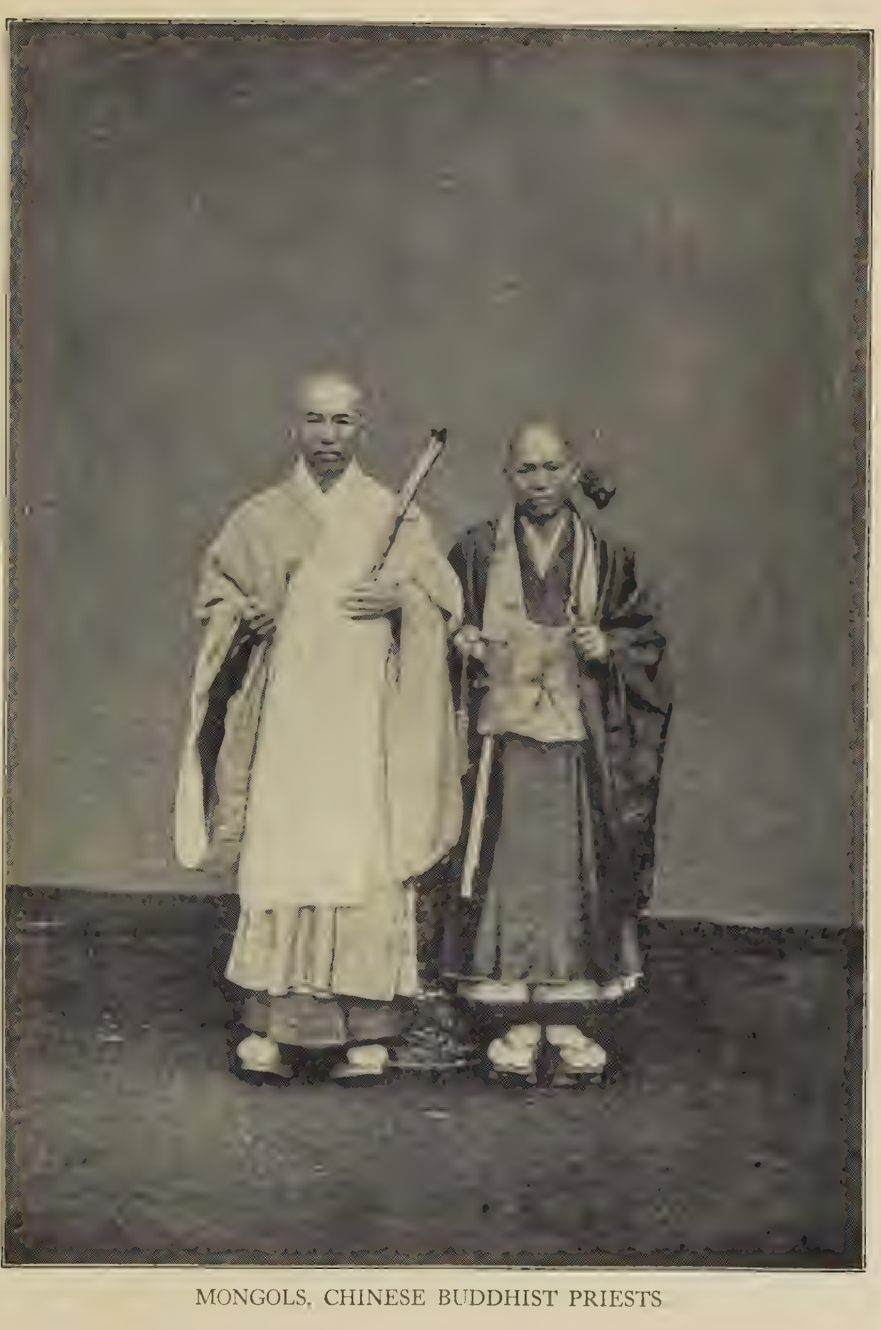
It is also more adapted to ground dwelling and an upright gait.

of man in Europe begins. But the examination of prehistoric records in Africa and Asia is still too incomplete to permit even guesses. A convenient hypothesis is to think of man's ancestors as setting forth in a long series of waves from this common centre of his development, broken here, failing there, but slowly peopling the world, and each taking on the color and character produced by his peculiar habitat. The ancestors of the Negroes drifted southwestward into Africa and southeastward along the Malay Peninsula and the islands clear to Australia. The forebears of the yellow Mongols turned eastward into China and Japan, where the vast Pacific halted them for tens of thousands of years.


NEGRO FROM STANLEY FALLS, AFRICA.

Here is no one migration but the slow drift of peoples. At what point and by what route the first men came westward into Europe is unknown. But the Caucasian is a type markedly distinct from both Negro and Mongol, and his differentiation must have begun far back in the Great Ice Age. South, East, and West, then, these three streams of humanity have poured through the ages—to become, after tens of thousands of years, black, yellow, and white. It should be added that the yellow men pushed across Alaska in these far ages and became red men, the American Indians—or, at least, such is the prevailing hypothesis as to the origin of this rather puzzling race. If so, one can think of the two mighty streams of humanity, the East and the West, finally girdling the globe and meeting one another face to face in America. The victory has here been an easy one for the white man, the Westerner, who has for long been the great adventurer, the explorer, the developer of the earth. But the story of evolution should lead us to take a somewhat larger view of human progress and not lightly dismiss the yellow race. The Easterner has not been a success overseas, and he has preferred to stay at home and cultivate his own continent. For this present rough outline, one can think of the westward-pushing white men as spreading thinly far and wide over all the continents and all the seven seas; and of the yellow races as staying stolidly at home to become great reservoirs of humanity, piling up an enormous concentration of man-power, unhurried and unspent.

In this discussion of races and movements we have been ignoring the difficulties of mixed races and cross-currents. The endeavor has been to look beneath the turbulent confusion which the sea of humanity presents on its surface, to its



MONGOLS, CHINESE BUDDHIST PRIESTS

deep and invisible currents. What has been said can be thought of as true only when thus broadly applied.

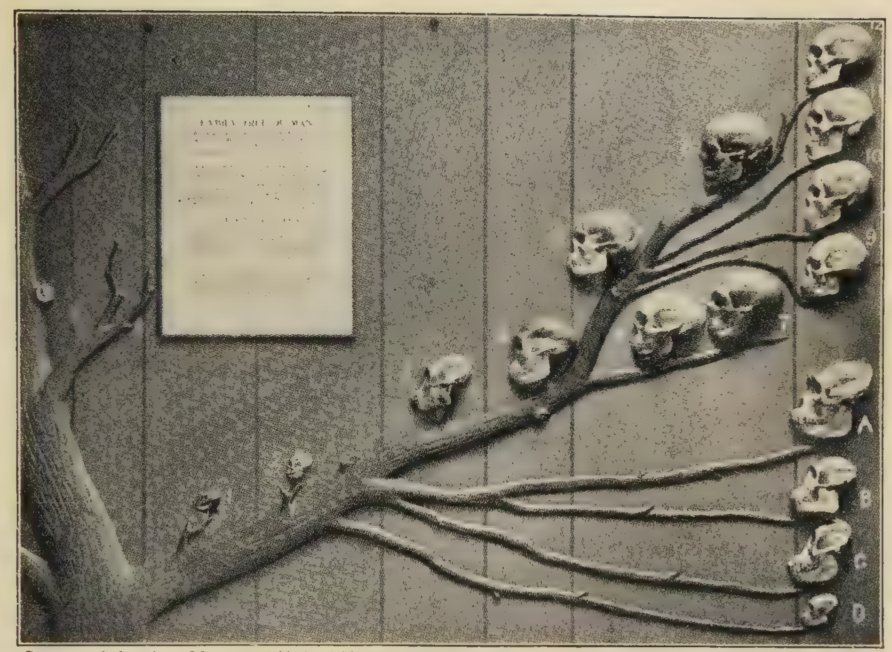
The development of the first four distinctive human powers can be discussed only in the same general terms. These are the erect attitude, the opposable thumb, the power of speech, and the new growth of the brain. It was the erect attitude which freed the fore paws of man's ancestors and enabled them to become hands, and therefore this attitude may be considered as the basis of man's whole progress. The ability to move the thumb so as to grasp a stick or a tool between it and the other fingers is of not less importance but it clearly followed in point of time. The beginnings of speech, however rude, doubtless came in this early prehuman period. All three of these factors developed the brain as it had never been developed before.

The old idea that man was but recently developed from a shaggy brute has long since vanished. When man first clearly appears upon the scene in the dim mists of time, he already walks erect, his thumb is well developed, the brain is far along the road to full human capacity. He feels some of the emotion that every one feels, love of family, loyalty to his group. There are few epochs of history as stirring as this first, long, up-hill battle wherein, for the first time in the world, a small, comparatively weak creature by sheer brain-power fought his way to mastery. Never have so many beasts of prey roamed the world as then hunted in the forests of Asia and Europe. From the valley of the Thames on the west to the plains of India on the east there was war to the death between sabre-toothed tigers, hippopotami, the mammoths, rhinoceroses, and every lesser carnivore. Man outguessed them all.

3. FIRST TRACES

The preceding section dealt wholly in surmise, in those first hypotheses of scientists based upon probabilities by which they begin to work. The next chapter will rest upon sure ground; the stone weapons and tools there to be described are as real and unquestionable proof of man's existence as an Egyptian pyramid or the Declaration of Independence. This section crosses an intervening field of increasing probability.

Parts of three early skulls (with a few other bones) constitute these first traces of man. The first skull was found in Java, the second fossil, a lower jaw only, in Heidelberg, Germany, the third in Piltdown, in Sussex, England. The first skull was found in strata probably contemporaneous with the beginning of the Ice Age in Europe—at least 500,000 years ago. The other two are later, how much later it is difficult to say. All three skulls have been studied by anthropologists for many years and a wealth of minute analysis and painstaking reconstruction has been made. In general, these three finds have withstood this cross-fire of criticism well. It is altogether probable that here are the skulls of three exceedingly primitive men. But as to specific details,



Courtesy of American Museum of Natural History.

THE FAMILY TREE OF MAN, SHOWING THE ASCENT OF MAN FROM LOWER MAMMALS.

1. Primitive primate.
2. Prototypal anthropoid.
3. Primitive anthropoid.
4. Pithecanthropus erectus.
5. Piltdown man.
6. Heidelberg man.
7. Neanderthal man.
8. Cro-Magnon man.
9. Australian black fellow, one of most primitive of existing human races.
10. Hottentot, representing the negro race group.
11. Chinese, representing the Mongolian group.
12. American, representing the Caucasian group.

A. Gorilla, Africa.
B. Chimpanzee, Africa.
C. Orang-utan, Borneo.
D. Gibbon, India.

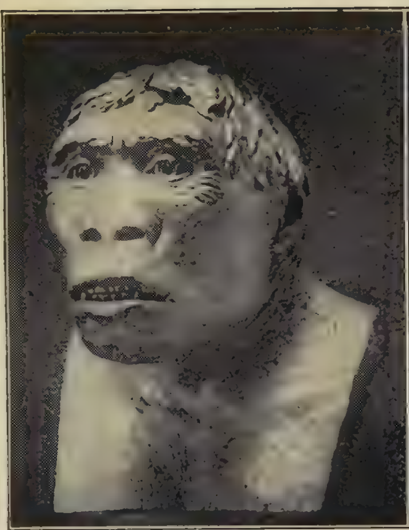
the precise period when each man lived, and the physical appearance of each, there has been much divergence of opinion and there remains great uncertainty.

Upon the basis of each skull it has been sought to reconstruct the type of being represented. The Java-skull type has been named pithecanthropus erectus, which is to say, "ape-man who stands erect." The top of the skull, a few teeth, and a peculiar thigh-bone (found about fifty feet away and perhaps belonging to the skull, perhaps not) are all there is to go by. He has been frequently referred to as the "ape-man of Java" and been hailed as the "missing link." How inaccurate this latter phrase is as applied to any one ancestor of man has already been explained. It is especially misleading when applied to a being as vague and hypothetical as the owner of this Java skull. Nor is the scientific name of "pithecanthropus" or "ape-man" much better. In all probability the owner of the Java skull possessed a brain far greater in size than that of the largest monkey brain, and the prevailing view tends to regard him as a true primitive man and not an ape at all. On the other hand, there are other scientists who contend that he was nothing but a huge gibbon, an ape and nothing more. Many interesting efforts have been made to picture this being, but not enough of the skull was preserved to make its shape, let alone its facial expression, clear. When other skulls of the same era have been discovered it will be time to attempt greater precision. For the present pithecanthropus belongs rather to the scientists who can debate his probable characteristics with a full sense of the grave doubts surrounding his misty existence.

The famous Heidelberg jaw was found in 1907 in a sandpit seventy-nine feet below the surface of a bluff in southern Germany. The skull had been destroyed, but fortunately the teeth, the most significant part of a skeleton, were well preserved, and there is now general agreement among scientists that here is unmistakably a chinless, primitive, human jaw. In some respects it resembles the powerful jaw of the modern Eskimo, who, like any primitive man, uses his teeth as tools for tearing hides or what-not. The strata in which it was found would place it long after the Java skull, roughly half-way between that beginning of the Ice Age and the arrival of Paleolithic man more than 100,000 years ago.

More of the Piltdown skull was found, but, unfortunately, so broken and scattered as to cast grave doubts on the reconstruction which has been attempted. It is probably later than the Heidelberg jaw and differs from it radically in head form. If the reconstruction in the British Museum is correct, here was a well-developed human brain (almost as large as modern brains) set in a skull with a jaw like that of a chimpanzee.

There are no unmistakably chipped stone tools or weapons in the strata with any of these early remains. But some scientists believe they have found rude stones, slightly chipped, which were the weapons of the Heidelberg and the Piltdown men. It would be expected that man developed his



Courtesy American Museum of Natural History.

PITHECANTHROPUS ERECTUS, THE APE-MAN OF JAVA.

This restoration and that of the Piltdown man are by Dr. J. H. McGregor.

PILTDOWN MAN.

Although the jaw is ape-like, the face expresses intelligence.

HEIDELBERG MAN. FROM A RESTORATION BY THE BELGIAN ARTIST MASCRE.

It is believed that Heidelberg man was less ape-like than he is here.

use of weapons in this fashion; before he learned to make weapons he grasped a branch or hurled a stone that fitted his hand. Unfortunately these early stones cannot be accepted with confidence as true weapons, for there is no proof that the slight chippings on them did not take place naturally, as the result of frost. It is only when stones are found unmistakably chipped by human hands that the Age of Paleolithic Man surely begins. The question of these earlier weapons must be left to the scientists for further study and decision. They probably belong with the other doubtful traces of man in this hour before dawn when mists still cling to the earth and one can dimly surmise shapes without being certain of their reality.

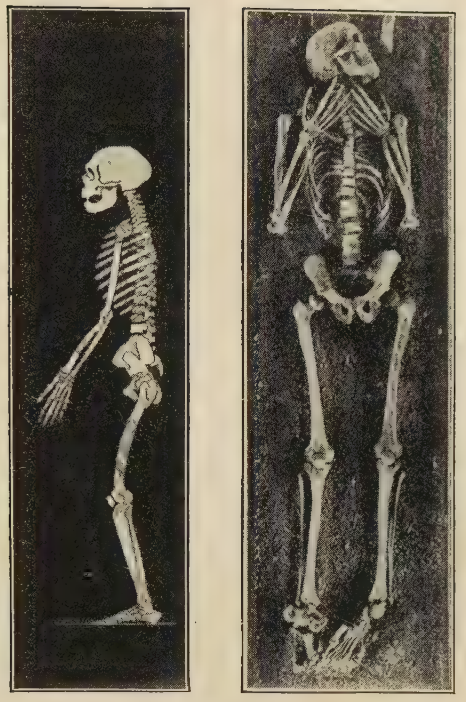
CHAPTER VII

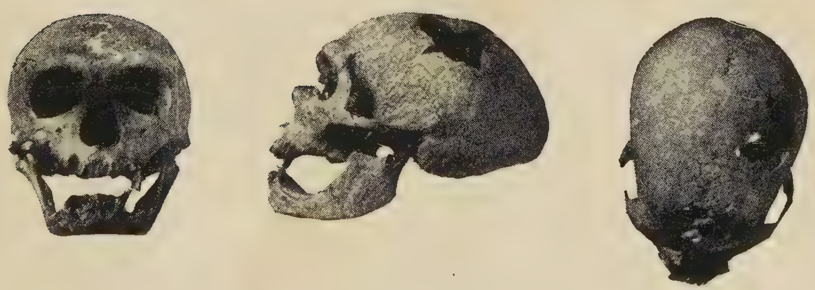
ANCIENT HUNTERS OF THE OLD STONE AGE

I. NEANDERTHAL MAN

Thousands of stone weapons and tools have been found to bear testimony to this period. Half-way along in it skulls and skeletons begin to appear. Parts of more than sixty human beings have been found who lived within its limits. In addition, there are, toward the end, cave paintings and bone carvings.

It is not a smooth, connected record. It breaks sharply as the first race of man declines and disappears and a new race arrives upon the scene. The Neanderthals were the first race. Among the later races was a far greater people, the famous Cro-Magnons, best known by their caves in southern France and Spain. From one point of view this break is an interesting landmark in the story of man, for the earlier race differed markedly from later Europeans and, in the opinion of most anthropologists, died out, leaving no descendants; whereas the Cro-Magnons far more probably may be numbered among our ancestors, our earliest known human ancestors. After a brilliant climax of art in the caves of France and Spain, their story ends in darkness. But that need not surprise one. All history is a succession of such





Courtesy American Museum of Natural History.

ABOVE—SKELETON OF A NEANDERTHAL MAN COMPARED WITH ONE OF A VERY TALL CRO-MAGNON.

The primitive character of Neanderthal man is clear in the short trunk with the outthrust neck and the outward bend of the knees.

BELOW—THREE VIEWS OF A NEANDERTHAL SKULL.

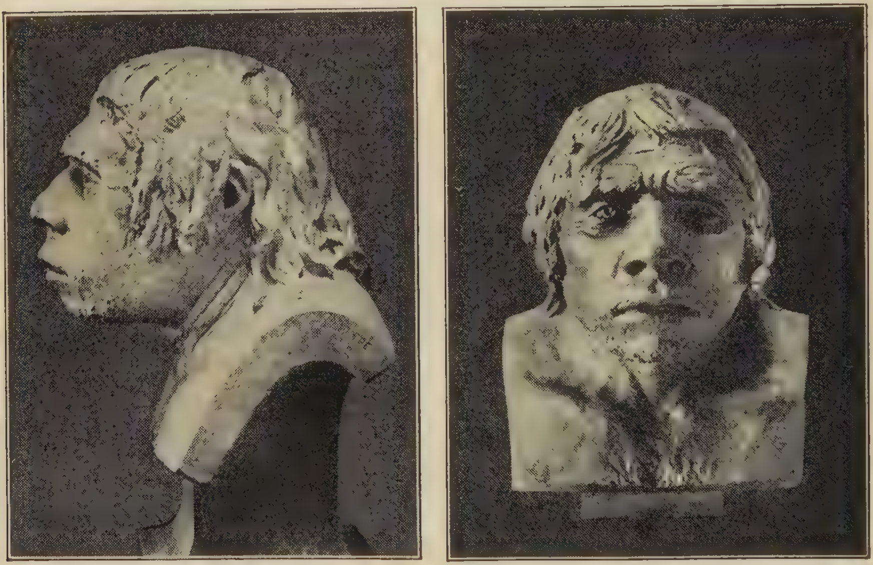
The large jaw and protruding eyebrow ridges are more anthropoid than human.

flowerings followed by decay as surely as night follows the day.

This record of stone tools begins in Europe in one of the warm spells between the extreme advances of the glaciers. For at least 50,000 years it is a question of stone relics only. Then begin to appear the human remains of the Neanderthal race. Roughly speaking, the story of these Neanderthals begins at least 50,000 years ago, and lasts until the final descent of the ice, perhaps 25,000 years ago.

The first traces of the Cro-Magnon culture appear as the last ice-caps retreat northward, and their culture, with other late cultures, lasts until the beginning of the New Stone Age, somewhere after 10,000 B. C.

The weapons of the Neanderthal men and their skeletons have been found widely distributed over Europe. There is a sufficient resemblance among the skulls and other bones to convince the anthropologists that here is a single race of primitive men that inhabited Europe throughout these 25,000 years. Very possibly their ancestors dwelt there for many thousands of years before; but lacking skulls or skeletons, one cannot be sure. There is some certainty, at any rate, as to how these early hunters looked. They were stockily built, standing about five feet six inches high. Because of the structure of their knee-joints, they could not fully straighten their legs. Their hands were large for their size and their brains were as large as man's of to-day. But the shape of the skull shows that theirs was a primitive brain; and the face was equally primitive, chin retreating, jaws massive, brows heavy and overhanging, forehead retreating. So far as can be judged from their skulls they were not far from the mental development of the lowest human races of modern times, certain



Courtesy American Museum of Natural History.

RESTORATION OF THE HEAD OF NEANDERTHAL MAN, AFTER THE MODEL BY J. H. McGREGOR, FROM THE SKULLS SHOWN ON PAGE 233.

natives of Australia, who are still alive, and the Tasmanians who died out in the last century.

It is chiefly by their stone weapons and tools that scientists surmise the manner of life of these first Old Stone Age men. Only a brief summary can be devoted to the gradual development of these flint pieces. In a museum one can in a few minutes stroll past rows of them covering the whole period. From a modern point of view the progress won is small. Yet their story is the story of some 100,000 years, fifteen times the entire historic period from the discovery of bronze to the invention of flying-machines and wireless telegraphy.

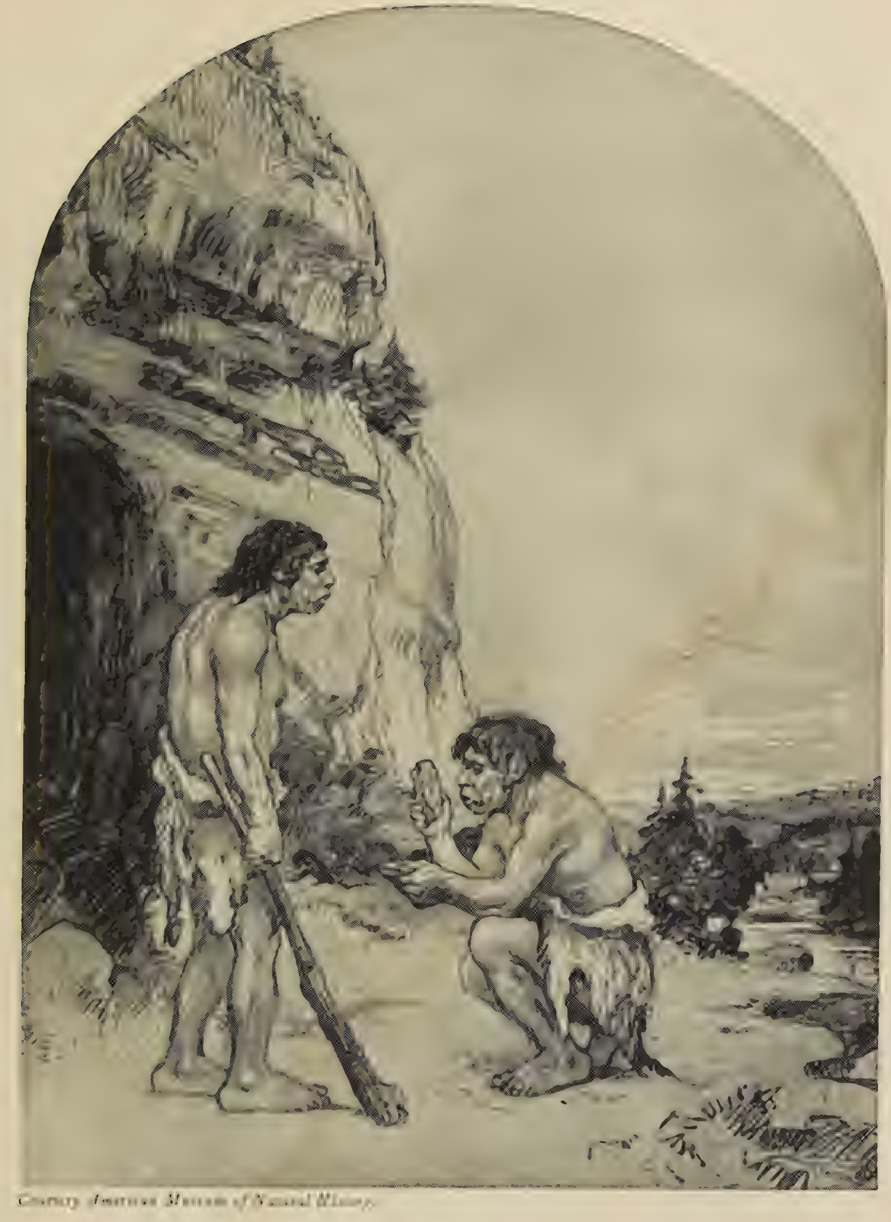
The *coup de poing*, or "fist-hatchet," was the chief tool and weapon of these first-known men of Europe, and it shows a continuous development into and through the period of the Neanderthals. It was from four to nine inches long, more or less almond-shaped but decidedly thicker at one end. It had sharp edges and a thin point, and was made by chipping rough flakes from an oval lump of flint. Held in the hand by the thicker end, it could serve as dagger, knife, saw, or spade. Turned end for end, it made a good enough hammer. It was a combination tool. In the earliest strata the chipping is slight and rough. In the course of 100,000 years the Neanderthals

From a "Times" World Copyright Photo.

A NEANDERTHAL FAMILY OUTSIDE THEIR CAVE-DWELLING.
From a group of life-size figures at the Field Museum of Natural History, Chicago.

and their forerunners learned to chip much more expertly and to turn out different kinds of fist tools each fitted for a special use, for scraping, for boring, etc. They also made small pointed flakes of flint, but there is no evidence that they ever used them as spear or arrow heads. Toward the end of the 100,000 years the tools became smaller and the chipping rougher. At the same time these primitive men took to the caves, perhaps because the coming glaciers sent the breath of their cold before them. Mousterians these men are sometimes called, after a famous cave in southern France. They are the first of the cavemen.

It is not necessary to dismiss these Neanderthals and Mousterians as so many vague hairy fellows squatting around Europe. They were hunters, for they killed and ate wild animals, from the woolly rhinoceros down to the ponylike horses that then trotted around Europe. This is known, because the remains of these animals have been found with Neanderthal tools. How they killed the giant carnivora is not as clear. The *coup de poing* was no weapon with which to face a woolly mammoth or a lion. The sabre-toothed tiger had vanished, but most of the other great Quarternary animals still roamed the jungle where now is Paris, and across the dry land where to-day is the British Channel to the valley of the Thames flowing past uninterrupted forest. The surmise is that they trapped them in pits, and some British scientists believe that they have found in Dorset remains of a great elephant-trench. It was one hundred feet long and twelve feet



Courtesy American Museum of Natural History.

NEANDERTHAL MAN AT THE CAVE OF LE MOUSTIER, DORDOGNE.

From a painting by Charles R. Knight.

deep, open at one end, closed at the other. African natives trap, disable, and kill elephants by driving them into just such pitfalls to-day. Perhaps the Neanderthals were as clever. They were certainly clever with their hands at chipping flint, as any one can find out by trying to make a stone tool as sharp and symmetrical as any *coup de poing* of the Neanderthals. Also they had fires, for their hearths have been found. So they may have cooked their meats. The scraping tools point pretty clearly to their preparing hides, and as they lasted into an era of great cold, it is probable that they dressed in skins. No trace of any domesticated animals has been found—not even a tamed wolf-dog. The Neanderthal man ate his horses instead of riding them.

There are also facts like the following. In the famous grotto of Le Moustier in southern France there was found in 1908 a complete Neanderthal skeleton. It belonged to a boy, perhaps sixteen years of age. The body was carefully laid out, the head resting on a pile of flint fragments carefully set together. Close by the right hand was a beautiful *coup de poing*, of exceptionally fine workmanship. Around the body were the split and charred bones of wild cattle. All this was an unmistakable burial similar to countless ceremonial burials of later times. So here was respect for the dead, perhaps love of a child, and certainly a thought, however dim, of some kind of life after death. Was this religion? These early beginnings of belief will be examined together a little later. For the moment, it is plain that however savage a creature

Neanderthal man may have been, he was already, 100,000 years ago, far removed from ape or any animal. One must be careful not to romanticize him and read into him one's own ideas or even the ideas of savage man of to-day (who has these 100,000 more years of experience to his advantage). But if one pictures him squatting before his cave, shaggy, dirty, his great nostrils quivering as he tears the meat from a bone with his teeth, one must equally do him the justice of picturing the human emotions already stirring within him, forerunners of all civilization.

Courtesy American Museum of Natural History.

SKELETONS OF A DISTINCT RACE, THE GRIMALDI, WITH NEGROID CHARACTERISTICS.

The Grimaldi are believed to represent a type intermediate between the black and white races, flourishing some 25,000 years ago.

Neanderthal man vanished, perhaps killed by the cold or an icy flood, perhaps killed by his successor, the superior Cro-Magnon man, who arrived from the south with spear, and maybe arrow. Most anthropologists view him as a dead end, a blind alley, passing on nothing to his successors. It is interesting to study him, however, because his fate yields thus early an example of the rise and fall of peoples. Neanderthal, Cro-Magnon, Neolithic man, Egypt, Babylon, Persia, Greece, Rome, all have shared the same growth and decline. The Neanderthal was unlucky if he left not even his blood to flow in the veins of descendants. In historic times there seldom or never has been a complete extermination of a race, however abjectly conquered. But touching power, achievement, growth, the story is the same. The Neanderthal rise and decline parallel the career of one civilization after another.

The story of these Old Stone men of Europe who chipped their flint tools, without polishing them, for 100,000 years or more, is the one clear record of this stage of man's progress that is known. Similar tools found widely distributed on other continents suggest that man all over the world went through a similar stage. They are lacking in Norway and Sweden and elsewhere throughout the region of the glaciers, areas which were uninhabitable during the European period of this development. In North America many Indians never progressed beyond chipped stones. Hosts of savages the world around, in Africa, in Australia, in Oceania, shared the same fate. But the records of this age are too fragmentary save in Europe to write all its chapters. Archæology is a young science, and it is naturally in Europe, the birthplace of modern science, that it has made the most progress. One must therefore avoid the mistake of thinking that this early European record, ingeniously pieced together by scientists, is unique.

THE STONE ARROW-HEADS, SPEAR POINTS, AND OTHER IMPLEMENTS OF THE AMERICAN INDIAN RESEMBLE BOTH OLD AND NEW STONE AGE TOOLS.

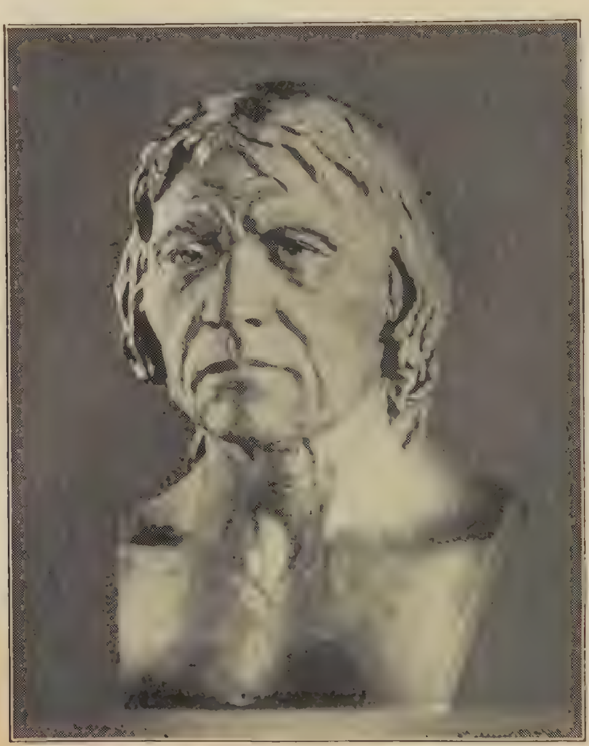
To the contrary, it probably represents a long chapter in the history of most human races.

The time at which it occurred varies greatly in different quarters of the earth, and in the present state of knowledge it is impossible to say with certainty whether, for instance, the Old Stone Age in Asia came before or after that in Europe. But in the New Stone Age western Asia, Egypt, and Greece were one or more thousand years in advance of western Europe; similarly, the Bronze Age and the Iron Age began one or two thousand years earlier in this region. Perhaps in the same fashion, when modern science can penetrate to the heart of Asia, it will be found that Paleolithic man learned to chip flint tools there long before his European brother. If so, there would be a neat story of man's progress that might fit in well with the theory that he originated somewhere in central Asia. But history is seldom neat, and this leadership of Asiatic man in the Old Stone Age is still surmise.

2. THE GREAT CRO-MAGNON RACE

By the fact that he did not polish his stone tools the Cro-Magnon is classed with the Neanderthal man in the Old Stone Age. His immense superiority over his predecessor is obvious and clearly justifies separate treatment. His story is one of the most amazing chapters in human records.

Physically he was a singularly fine type of modern man, one of the finest the world has ever seen. He stood six feet tall and had a brain capacity well above that of the average man of to-day. The meaning of this must not be exaggerated, however; quantity is important in brains, but quality is the decisive factor. His forehead was high and broad, his nose aquiline, his chin prominent and massive. His head had one striking peculiarity; it combined wide cheek-bones with a narrow skull. That is a rare type, and on the basis of it anthropologists have attempted to trace Cro-Magnon blood among Europeans of to-day. It is an extraordinary fact that the same peculiar skull still exists among the inhabitants of the valley of the Dordogne in France, where these Cro-Magnons especially flourished. It is also found in Brittany and the Canary Isles.

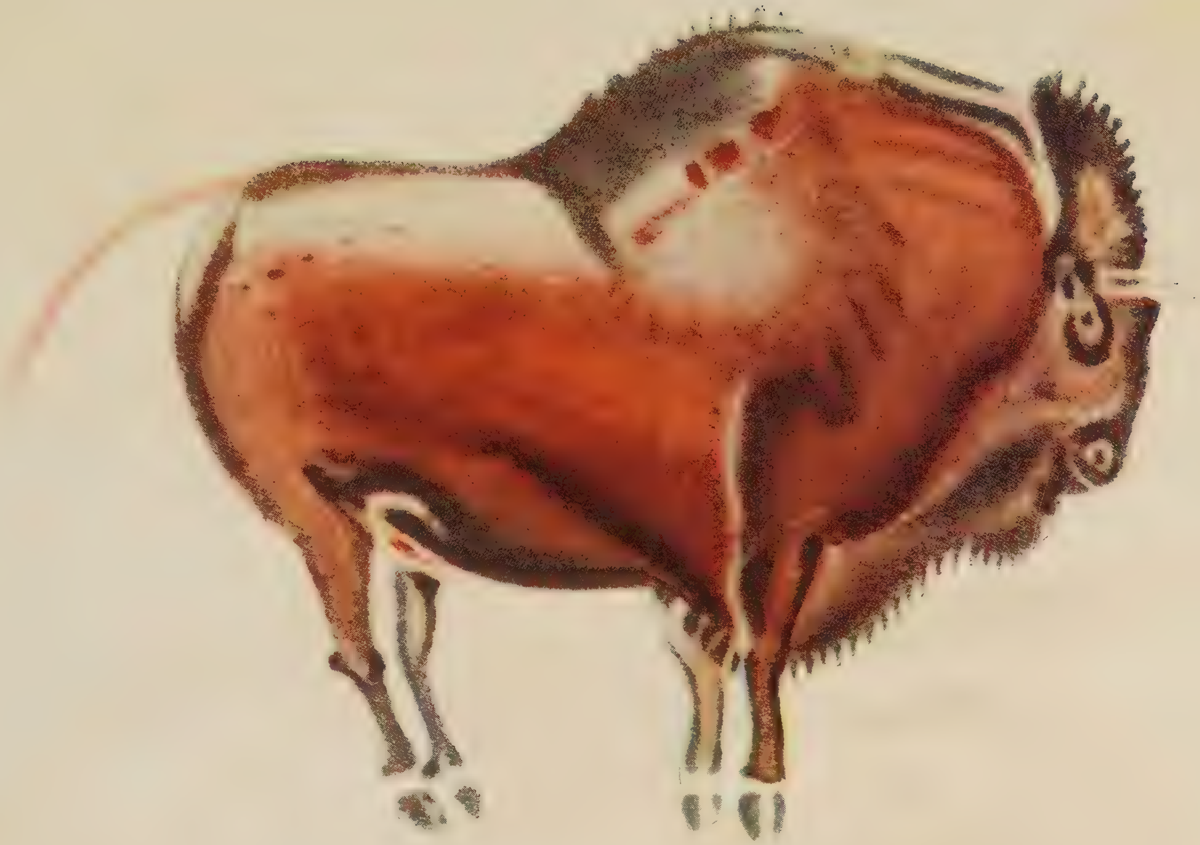


Courtesy American Museum of Natural History.

A RESTORATION OF THE HEAD OF A CRO-MAGNON, MODELLED BY J. H. McGREGOR.

This is a direct ancestor of *Homo Sapiens*, and descendants of this long-headed race exist today, especially in the Dordogne Valley in France.

The Cro-Magnons were the famous cave-dwellers of southern France and Spain. Whether they drove out and killed the late Neanderthal men, the Mousterians, or whether these predecessors had already died off, is not known. They

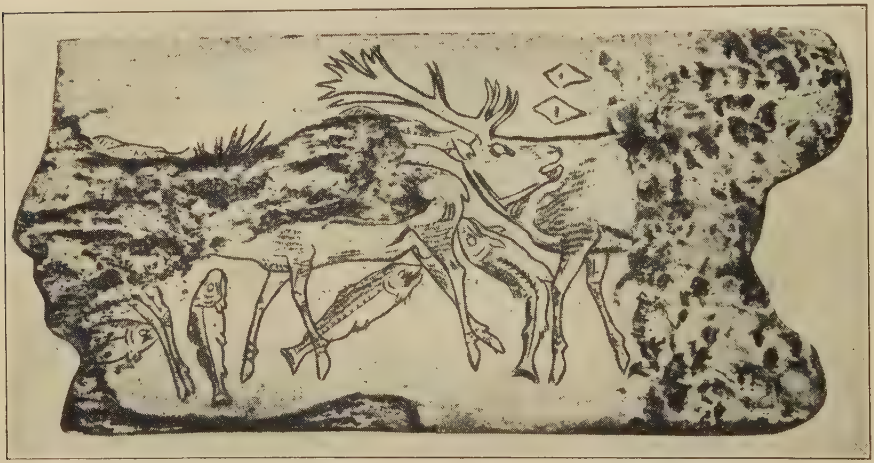


A BISON PAINTED ON THE CEILING OF A CRO-MAGNON CAVE AT ALTAMIRA, IN NORTHERN SPAIN.
This fresco shows Cro-Magnon art in its highest form, with four separate processes employed to obtain the final polychrome painting.
After Breuil.

moved into the caves, at any rate, and their remains are found in the strata above the Mousterians. They were great hunters and fishermen. The reindeer, roaming the Pyrenees as the last ice-floes slowly retreated northward, was their especial prey, and the time is therefore often spoken of as the Reindeer period. Bison, bears, elephants, ponies were equally their kill. They never polished their stone tools but they learned to turn out exquisite pieces of workmanship by chipping, far superior to the best Neanderthal work. In the height of their progress they discovered the possibilities of bone and horn, and gradually developed the manufacture of bone harpoons for fishing, bone barbs for spears, and bone needles for sewing.

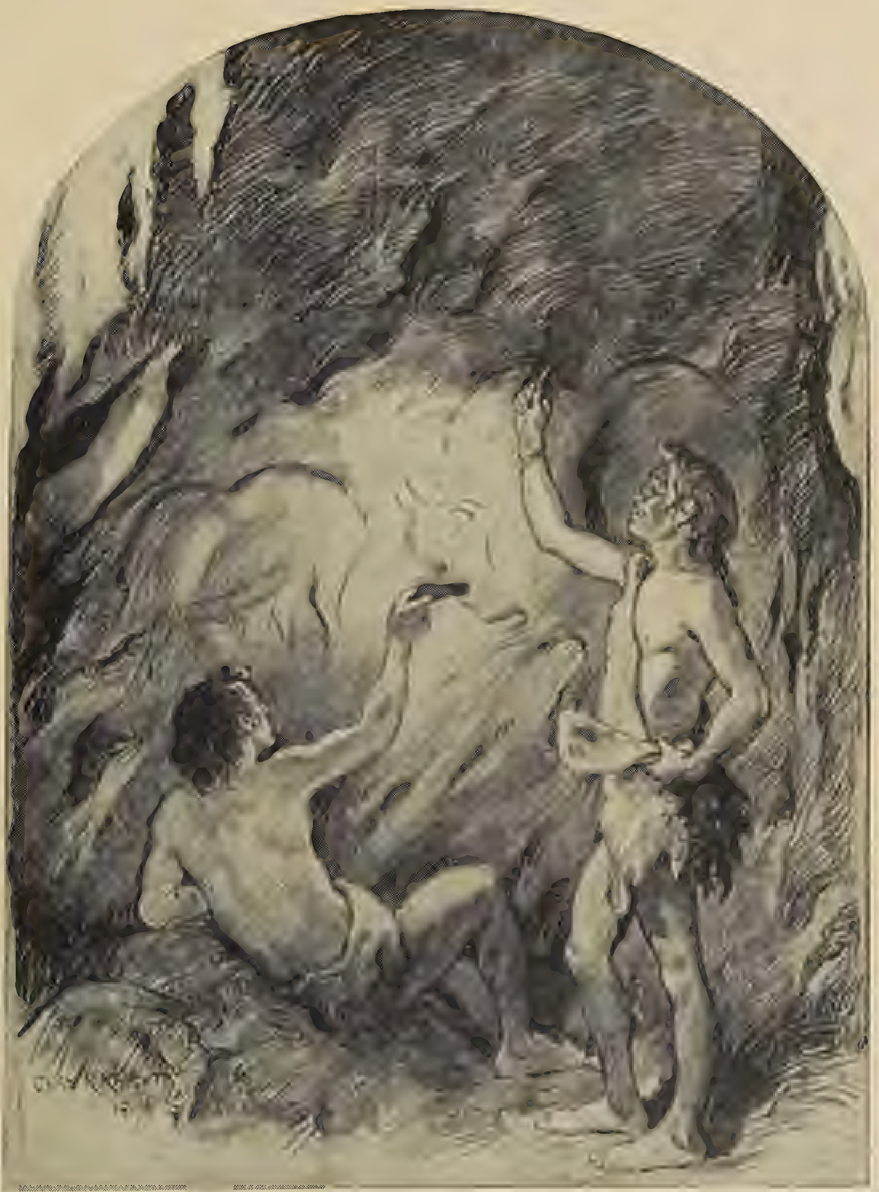
It is their art, their drawings and paintings on the walls of caverns, and their carvings of bone and ivory that have brought them their chief fame. Here in these dim caves, at least 15,000 or 20,000 years ago, these ancient hunters learned to draw animals with a skill that has never been surpassed. No modern animal-painter does better than these drawings, literally the oldest pictures in the world. No man of historic times has seen a hairy mammoth alive; thanks to these Cro-Magnon artists, we have a perfect idea of them. There are several distinct varieties of horse (including the wild ass) shown. The bison was a favorite subject, and at the height of Cro-Magnon art inspired some wonderfully lifelike and decorative pictures. These wall and ceiling paintings are fairly large; the animals are often four or five feet long. The carvings on horn are necessarily small but of equal artistic merit. The history of this art shows just what might be expected from the records of modern civilizations, crude beginnings, a steady increase in skill and variety to a perfect flowering, and finally decline and disappearance.

One extraordinary feature of these paintings is that they were painted in the dark, for the most part, in the far depths of meandering caverns, sometimes hundreds of feet from daylight. The artist must have worked by torchlight and he must have worked from memory, with no model before him. Often the best paintings are in the innermost recesses, small caves to which one must crawl on one's hands and knees. Modern art is a thing to be displayed, either in churches or homes or museums. From the days of the Greeks onward,



STAGS AND SALMON ENGRAVED ON AN ANTLER.

This design, which represents a herd crossing a stream, is unique in that it is one of the rare attempts at composition.



Courtesy American Museum of Natural History.

CRO–MAGNON MAN IN THE CAVERN OF FONT–DE–GAUME, DORDOGNE, RESTORED IN THE ACT OF DRAWING THE OUTLINES OF ONE OF THE BISON ON THE WALL OF THE CAVE.

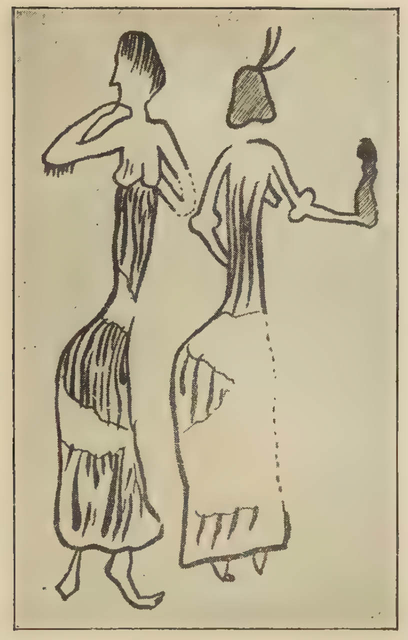
From a painting by Charles R. Knight.

artists have made beautiful things to awaken high emotions in as many people as possible. Why did these first great artists work thus far away from daylight and a public?

The answer is by no means certain, but the hypothesis upon which archæologists are working is that the paintings formed part of a primitive faith. This form of worship is frequent among living savages to-day. Among certain tribes of Australia painting the picture of an animal on a rock, or the symbol of an animal, forms a regular part of solemn ceremonies by which good hunting of that particular animal is sought. Now it is a striking fact that all the animals painted in these caves were animals that it was desirable to hunt and kill. The lion lived in these years, but not a single picture of the lion, a dangerous animal of little value, has been found. Nor is there a picture of a hyena, a jackal, a wolf, or a serpent. The guess is that these Cro-Magnon paintings were the work of priests, trained, highly skilled craftsmen, who drew these pictures of bison and reindeer and mammoths, probably chanted sacred words before them, perhaps whirled a stick about to make a noise, and, thus worshipping in their primitive fashion, counted upon gaining a fat kill for the waiting huntsmen without. If so, there is justification in the comparison which R. R. Marett, the British anthropologist, makes between a Cro-Magnon cave and a cathedral. Thousands of years separate the conceptions involved. Not enough of savage ideas is yet understood to say whether such rites deserved to be classed as truly religious. Perhaps magic, the forerunner of religion, is a more accurate term. Yet these men made frescos, wonderfully beautiful ones, quite as civilized man has painted frescos in his cathedrals. They had the majesty of dim lights and a stone hall. They were seeking to solve the mysteries of life by such rites as they knew.

Nor was the art of the Cro-Magnons restricted to these religious paintings. As among every artistic people, the effort to beautify extended to every utensil of ordinary life. They carved their javelin points, their dart-throwers, and their harpoons. The red deer on the most famous of all Cro-Magnon drawings were engraved on an antler of a deer, and the horn thus decorated was perhaps a ceremonial wand, a sort of primitive sceptre. There are not many attempts at the human figure by these Cro-Magnon artists. But there are a few sculptured works, including the head of a woman wearing a striking head-dress. There are also in one Spanish cave the drawings of some women with strange high hats, narrow waists, and flaring skirts. No fashion-plate could give a clearer idea of a costume, and it is anything but the dress of a savage.

Unfortunately, the Cro-Magnons did not have a written language, as far as is known; and if they had homes other than caves, they were doubtless tents of skins which have left no trace. It is known that they buried their dead carefully amid small perforated sea-shells and surrounded by yellow ochre or a red coloring matter, the same colors in which they painted their bison on the cave walls.



Female figures painted on the walls of the Cueva de la Vieja in Spain.

Antelope carved on a bone dart-thrower. From the Mas d'Azil, France.

Batons de commandement, of carved reindeer horn, may have been used as symbols of authority by the chieftains.

ART OF THE LATE PALEOLITHIC RACES.

This extraordinary people possessed an infinitesimal part of all that modern man regards as civilization, yet rivalled his best in the matter of pictorial art. Historians who care little for art have been disposed to dismiss the Cro-Magnon pictures as simply another example of primitive, savage art. It is true that savage tribes often do have an interesting sense of the beautiful and that some skill in drawing is found among low civilizations. But the Cro-Magnon art, according to those best qualified to speak, the artists, is something different. It so far surpasses all other savage art, in observation of nature and the portrayal of the simplest essentials of form,

Courtesy American Museum of Natural History.

SOAPSTONE FIGURINE WHICH MAY HAVE BEEN INTENDED FOR AN IDOL.

It is an example of early Cro-Magnon work.

WOMAN WITH HEAD-DRESS SCULPTURED IN IVORY.

These statuettes are very rare, and represent the art of later Paleolithic Cro-Magnons.

as to place its creators in a class by themselves. "What is a savage, anyhow?" one is tempted to ask before this race of mighty hunters and mighty artists. It is to be hoped that more will be discovered concerning them and that scientists will some day better understand how they accomplished so much with so little; how, in the cold of retreating glaciers, sheltered only by caves and tents, living as lived the redskins by fish and game, they yet handed down the ages beauty of which Greece or Rome or the greatest moderns might be proud.

CHAPTER VIII

HERDSMEN AND FARMERS OF THE NEW STONE AGE

THE scene changes and man changes with it. There could not be a sharper contrast than that between the Europe of the Old Stone Age and the Europe of the New Stone Age, between the hunters who dwelt in Europe down to 10,000 B. C. or thereabouts and the flock-tending, land-tilling men who came after. The last glaciers retreat into the arctic circle, taking the reindeer with them. Mammoth and elephant vanish from the south of France; the rhinoceros no longer swims in the Thames; oak and fir give way to chestnut and beech. The land bridges across the Mediterranean are broken down; England begins her island story. The Europe of to-day has arrived, and in its mild climate and upon its fertile soil are laid down the foundations of the Western world.

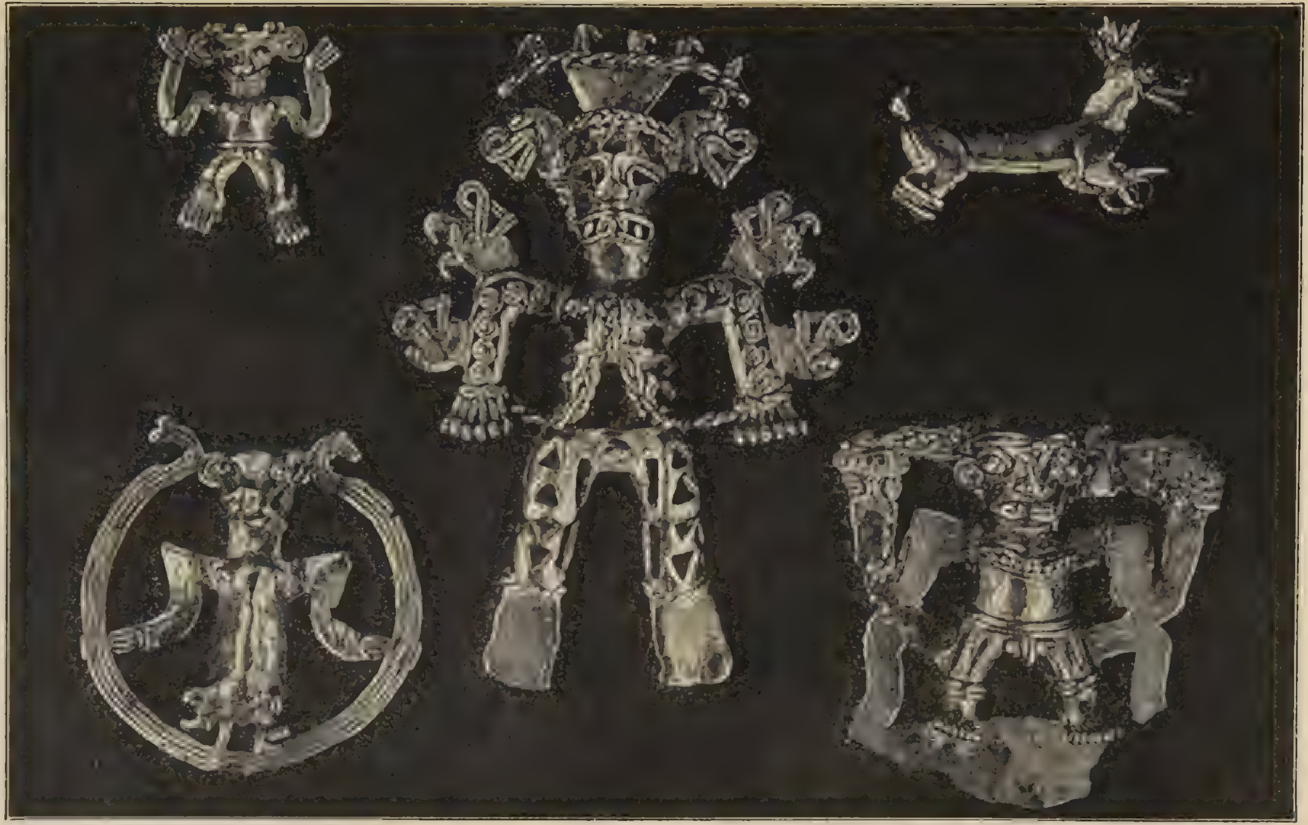
One must study this age in Europe where the records are fullest. But, as with the Old Stone Age of hunters, it is to be viewed as a general stage of progress, and in fundamental achievements has been passed through by most peoples of the world that have advanced out of savagery. It did not, however, occur at one time the world over or last a uniform period or reach a uniform height of civilization. The New

Stone Age in western Asia, Egypt, and Greece began sooner and ended sooner by a thousand years or more than in western Europe. The Americas were probably thousands of years behind Europe. In North America the mound-builders of the Ohio and the Mississippi valleys represent somewhat the same stage of civilization; they arrived late, and their successors, the Indians, never progressed farther, perhaps even retrograded. The Mayas of Guatemala and Yucatan and the Incas of Peru reached a similar stage at a date as yet undetermined, but certainly much later than Europe. They achieved an extraordinary civilization in stone and were working gold, copper, and silver when the Spaniards conquered them. The Mayas had already abandoned their stone temples and were declining at this time. The Incas of Peru were still flourishing, and might well have flowered into a great civilization but for the cruel conquest that blotted out their hopes.

There were six main achievements of this age in Europe:

1. Polishing stone stools and weapons.
2. The taming of domestic animals.
3. The beginning of agriculture.
4. The making of pots.
5. The plaiting of baskets and the weaving of cloth.
6. The raising of megaliths, or great stone monuments.

It is by the polished tools that archæologists fix the limits of this period. Obviously there are more important achieve-



Courtesy of American Museum of Natural History.

GOLD WORK DONE BY THE PREHISTORIC INDIANS OF PANAMA.

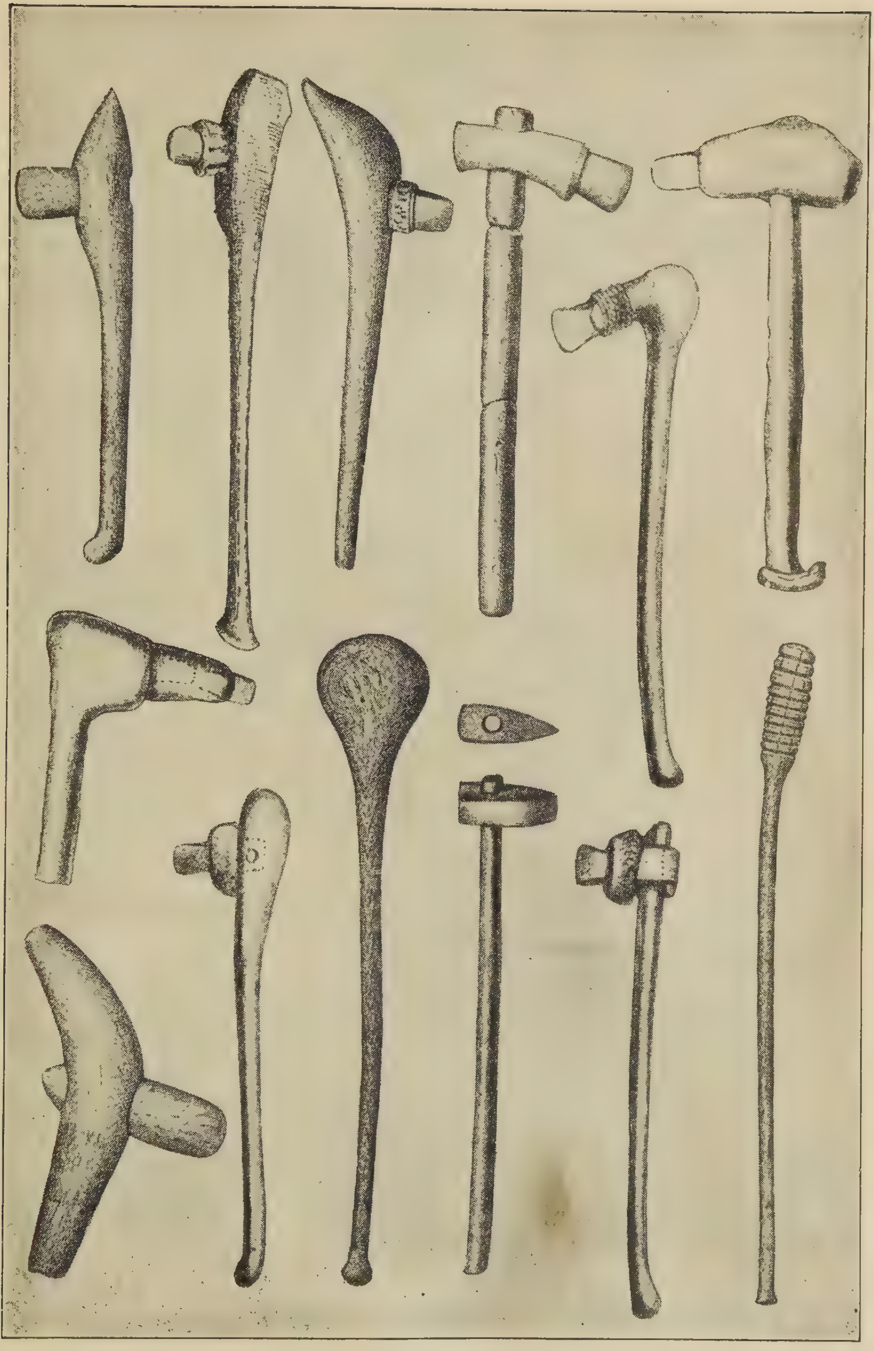
ments on the list, and the stressing of this item is simply a matter of convenience, based on the fact that tools have come down in quantity, and it is by them that the chronology of the period can best be fixed.

Nevertheless, the invention of polished stone tools was a long step ahead. Smoothing the surface of the stone axe enormously increased its efficiency, and as a farther improvement Neolithic man discovered how to put a handle to it, first by lashing it to the axe-head, later by boring a hole in the axe-head, like any modern axe. Alongside the axe slowly developed a carpenter's chest of tools—chisels, drills, and saws. Some Danish archæologists made the interesting experiment of seeing how much work a modern wood-chopper could do with these 6,000-year-old tools. In ten hours he felled twenty-six pine-trees eight inches thick and cut them into logs. A whole house was built by one man in eighty-one days, including the cutting of the timber. A wholly new level of mechanical skill was reached in this period, making possible for the first time the building of true houses. This rather obvious improvement in tools was a basic matter in the growth of civilization.

It may seem strange that it took 100,000 years for European man to discover this trick. Sand for polishing was at his elbow throughout this period; a whetstone could be had for the taking. The explanation is that most great inventions are childishly simple. There was writing in the world for 5,000 years before any one thought of movable type. Steam had been pushing lids off kettles ever since Neolithic times, but to no purpose until James Watt saw the steam-engine in it. Minds have improved, but that is a small part of the progress. The world advances faster than it did chiefly because of the accumulated wisdom of the ages which each generation now inherits. New ideas still come painfully and slowly. Original thinking remains the rarest thing in the world, exactly as it was in Paleolithic days.

It is in the kitchen-middens along the coast of Denmark, of some 10,000 years B. C., that the bones of the first domesticated dogs are found. These are long piles of bones and skulls, the refuse of prehistoric Norsemen who dwelt in wattle huts (made of plaited reeds daubed with clay) and pushed offshore in rude boats. It is possible that dogs were tamed by Paleolithic hunters; one cannot feel altogether sure of the negative evidence here. But it is fairly clear that the dog was the first wild animal to become the friend of man, and that this important event had happened before this time. This first dog of the Danish skull-heaps was of a jackal type like the modern Eskimo dog, but smaller; later a larger dog, more like the wolf, was tamed to guard sheep. He may have been the ancestor of the modern collie.

All this was in the rude beginnings of Neolithic culture. To see the full gains that followed, one must go south to the lake-dwellers of Switzerland, the most complete record of any prehistoric man that has come down to us. In so doing one passes to the end of Neolithic time in Europe, around



POLISHED STONE AXES FROM LAKE-DWELLINGS SHOWING THE METHOD OF ATTACHING THEM TO HANDLES.

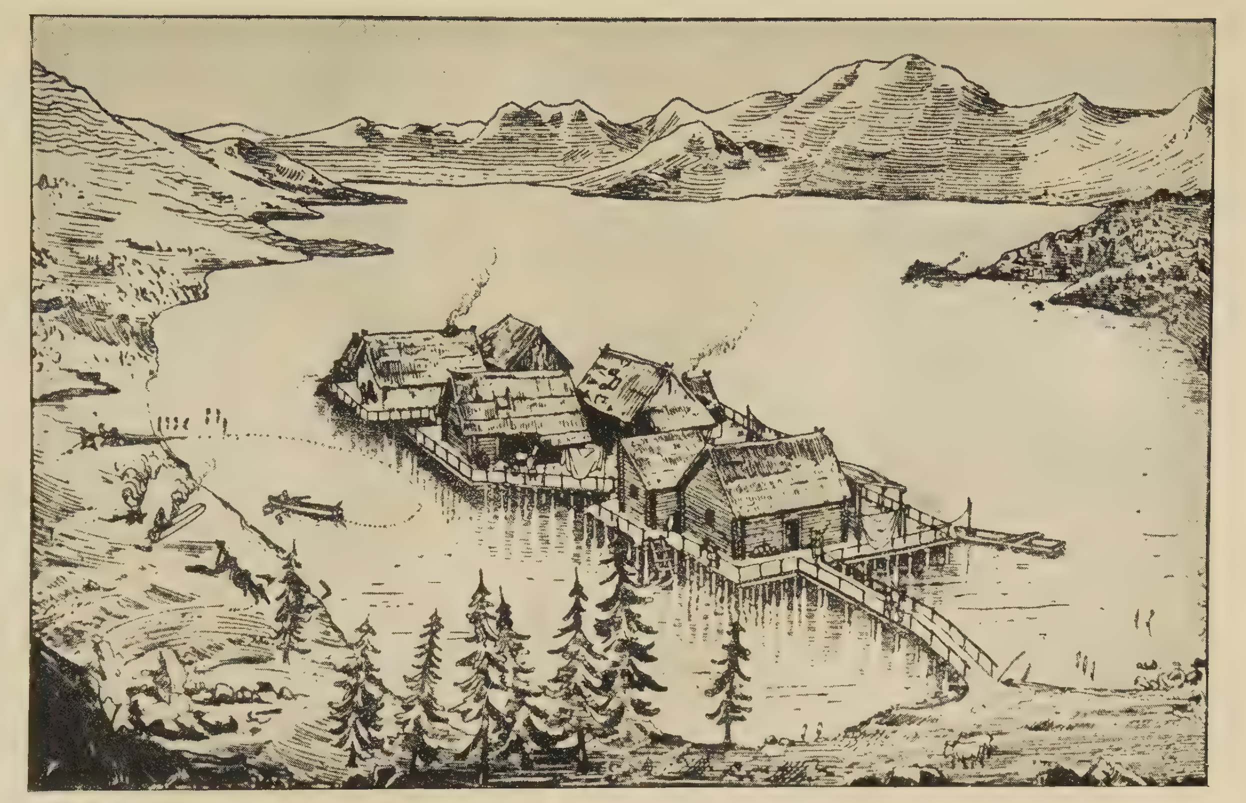
2000 B. C. The winter of 1854 was exceedingly cold and dry and, in consequence, the Swiss lakes sank to a lower level than ever before. In the wide mud-flats thus bared, there were discovered the tops of ancient piles, and near them bones, stone tools, and bits of pottery. Studying, collecting, and interpreting these strange records was a work of many years. Over fifty dwellings were found on Lake Neuchâtel and over forty on Lake Geneva and Lake Constance. Similar lake-dwellings have since been found wide-spread over Europe and in Britain. As many as 100,000 piles were used for one settlement. In some cases side-walls and floors have been found. Wattles covered with clay made the walls. The rooms were of large size, and there were stone slabs for hearths. A pile pathway connected the village with the shore. Tacitus, the Roman historian, writing of later lake-dwellers, noted that they tethered their babies to keep them from falling into the lake. The picture is of thrifty folk living in safety and comfort much as did the Swiss Family Robinson in their home in the tree.

From the bones found, the story of domestic animals can be completed. Cattle, goats, and sheep followed the dog, and later pigs. Some of these are simply wild types of the region. Others seem to have been imported from the East. All lived in the pile buildings with their owners, much as in the Swiss châlet of to-day. There is no record of this important process of domestication. One can surmise that it took place slowly, through the gradual discovery that such animals, herded and cared for, were more useful than merely hunted. The change was of prime importance to man, for it marked the end of the huntsman and the rise of the herdsman. Neolithic man continued to live largely by the chase and fishing—men still hunt and fish to-day. But the main interest of his life was no longer in the forest.

With this shift is to be classed the beginning of agriculture. The hunters had always eaten wild berries, nuts, and fruits. Neolithic man undoubtedly harvested wild grains before he learned to plant them. Barley and wheat were the first grains grown. Much later, in the Bronze Age, appeared oats and rye. (American corn or maize is a purely American growth. It was the chief grain cultivated by the Indians when America was discovered.) Whole bushels of grain have been discovered in the remains of these lake-villages, as well as charred loaves of bread and hand-mills for grinding flour. No plough has been found, and perhaps these lake-dwellers still did all their farming with primitive hoes.

Every house had its loom, and cloths of flax finely woven, some fringed and embroidered, have been found. It seems likely that they used the wool of their sheep, but no woollen cloth has been discovered. The pottery is primitive, made by hand, without a potter's wheel.

Although the remains are by no means as well preserved elsewhere, there is good reason to believe that this civilization of the Swiss lakes and the valley of the Po was widespread over western Europe at this time. The lake-villages



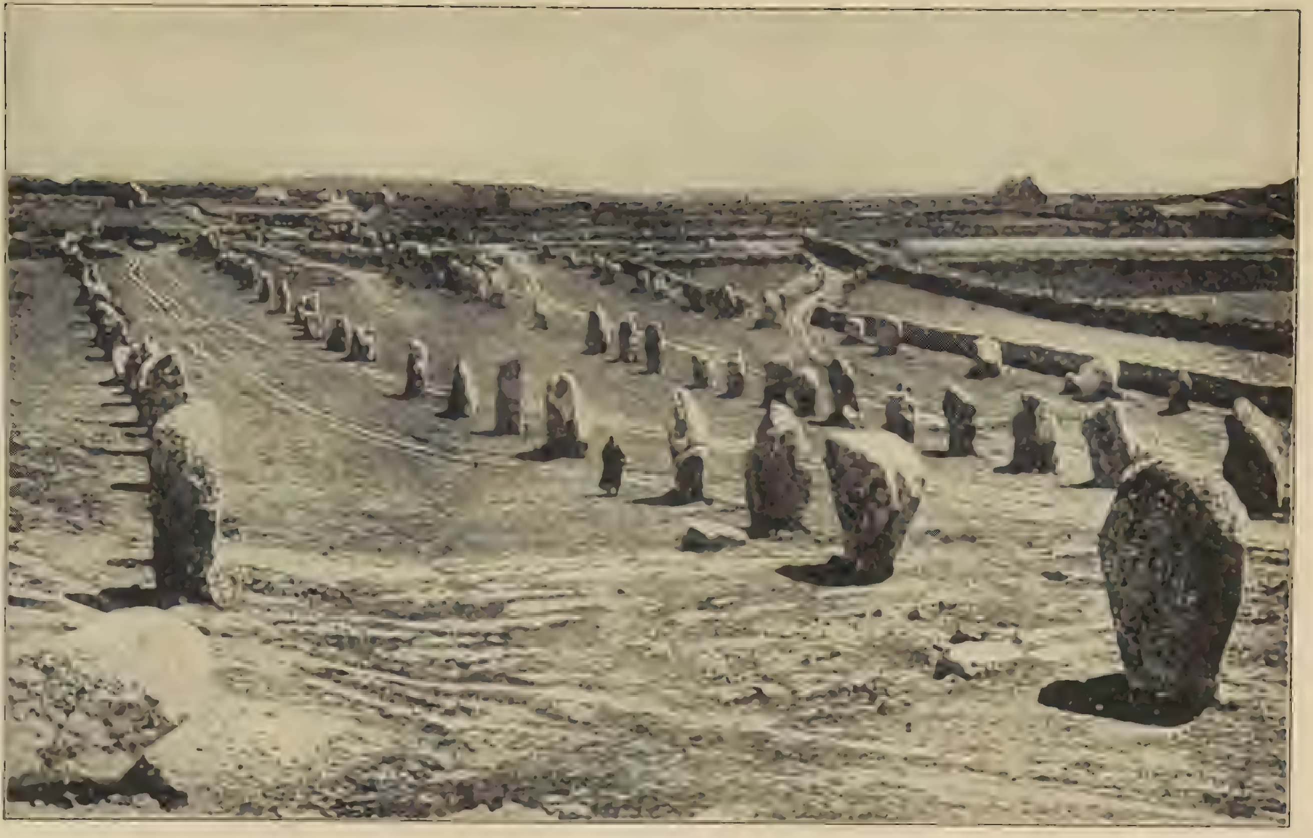
RECONSTRUCTED LAKE-DWELLINGS.

were especially safe and peaceful, and may have prospered beyond land villages. But if no other evidence were at hand, one could be sure that large settlements spotted western Europe by reason of the megaliths which date from this period. These strange monuments are found in many parts of the world, all of the same general type, and pointing to a general stage of civilization and faith through which many peoples, far distant from one another, have alike passed. They are found in Great Britain, Sweden, Denmark, North Germany, Holland, France, Portugal, and Spain, in Sardinia and Corsica, along the coast of North Africa, in the Ægean Islands, in Palestine, along the Black Sea, in Arabia, Persia, and in India. Perhaps the mounds of North America belong to the same stage. Certainly the stone structures of Guatemala, Yucatan, and Peru offer a close parallel.

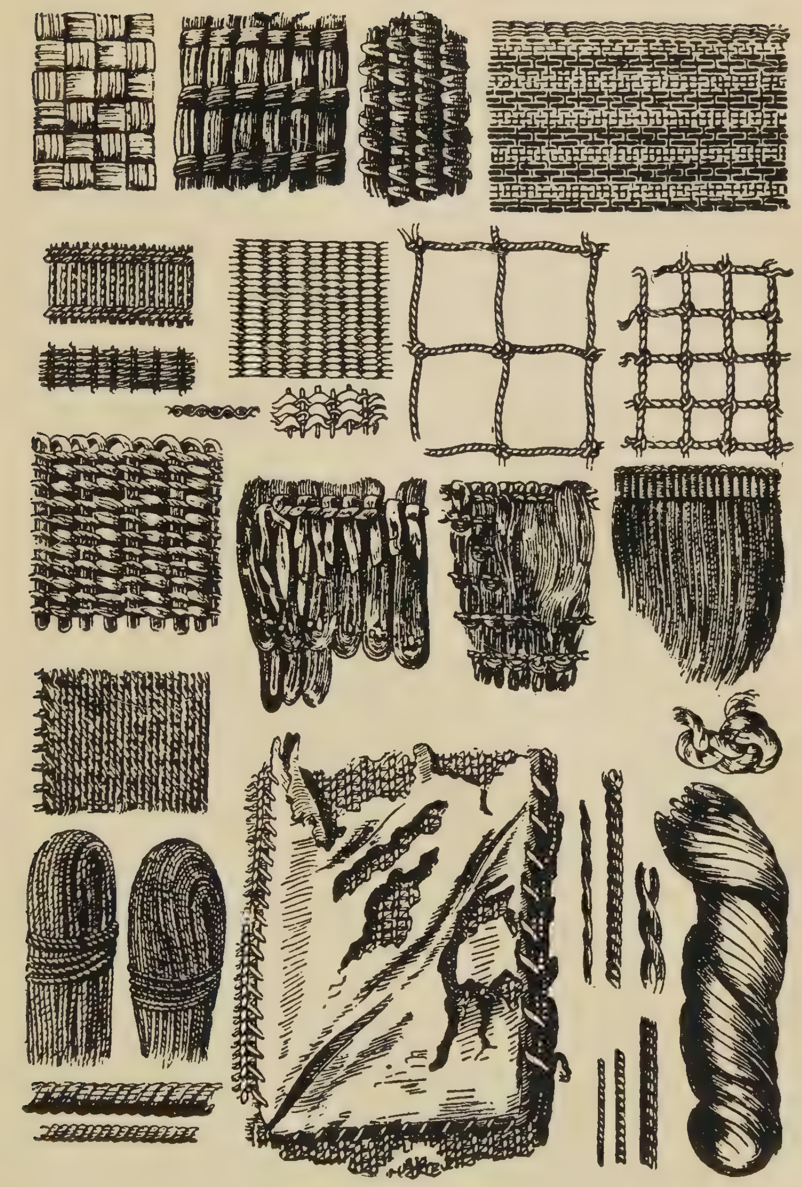
The huge stones are not architecture according to modern ideas of architecture. They are magnificent and impressive, none the less. The great circle of Stonehenge on Salisbury Plain in southern England is the most majestic of all. It is one hundred feet across, and its great upright stones are thirty feet high and weigh about thirty tons. This represents the very end of the New Stone Age (which lasted till 2000 B. C. in England) or perhaps the beginning of the Bronze Age. Its stones are more or less dressed, in this respect differing from the great majority of megaliths, which are simply huge works of nature transported and erected by man. At Stonehenge is an example of another frequent monument of this period, an alignment; that is to say, long rows of parallel stones, like a straightaway race-course. The most famous of these alignments is at Carnac in Brittany, a centre of megalithic remains. There are 113 parallel rows in these alignments, which are nearly 2 miles long. Many of the stones stand 10 to 13 feet high. Another common type of megalith was a great single stone called by its Breton name of menhir. It suggests the Egyptian obelisk in rude form. The largest of these, in Brittany, was 67 feet long and weighed about 350 tons. It is now fallen and broken in four places.

As to the exact purpose of all three of these forms of megaliths, there is doubt. The great circle at Stonehenge was most probably an outdoor temple. Efforts have been made to associate it with some form of sun-worship. But nothing has been established as certain. Similarly with the alignments. They suggest race-tracks, and it may be that chariots once rolled down them. But there is not the slightest proof of this theory. The menhirs may have marked boundaries or meeting-places; in most cases they are monuments to the dead.

There remain to be mentioned the most common of megalithic remains, the dolmens (another Breton word), which are unmistakably tombs. These range from a simple chamber of four stones on edge, with a great capstone across, to long covered alleys. The remains of the dead have been found so frequently in monuments of this type that their



THE ALIGNMENT AT CARNAC.

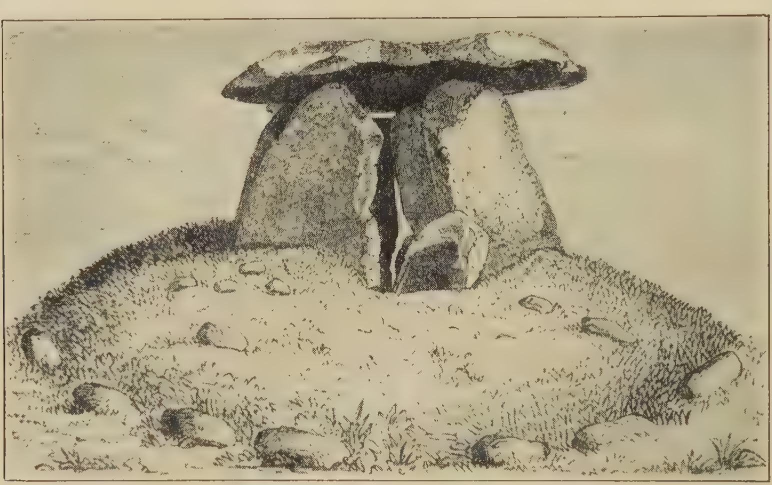


BEGINNING OF WEAVING IN EUROPE.

Cloth from the Swiss lake-dwellings was made of flax and the various weaves and patterns show that these people were experts in the art.

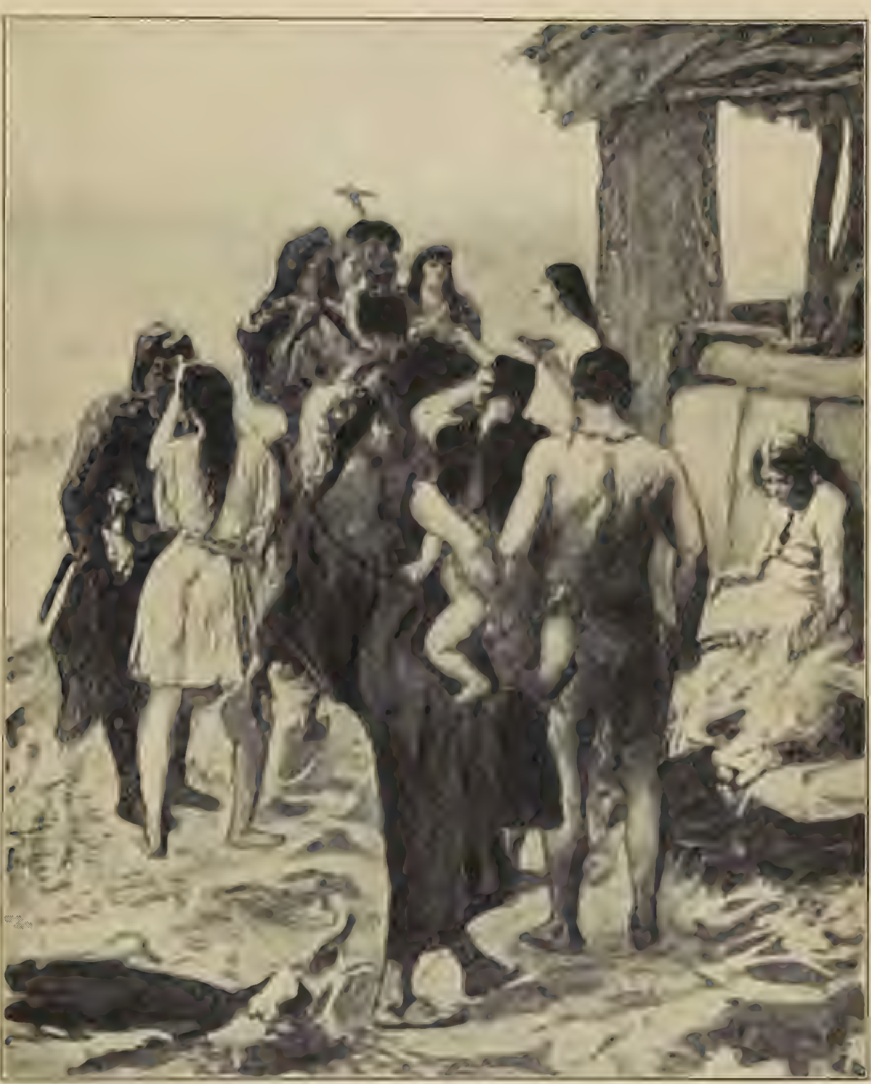
purpose is clear. The tumulus, or great mound, is also frequently found as a burial-place.

An extraordinary number of these great monuments still exist after many years of destruction and removal. There are nearly 4,500 in France and as many in England. Plainly Europe was well populated in this age, and there were villages of considerable size. Raising such huge stones is no easy task for a primitive people. There is no evidence as to how the work was done, but it is a safe presumption that inclined planes of earth were used and the power was furnished by a huge number of men, pushing and pulling. That is the way the great stones of the Egyptian pyramids were being erected about the same time.



A DOLMEN.

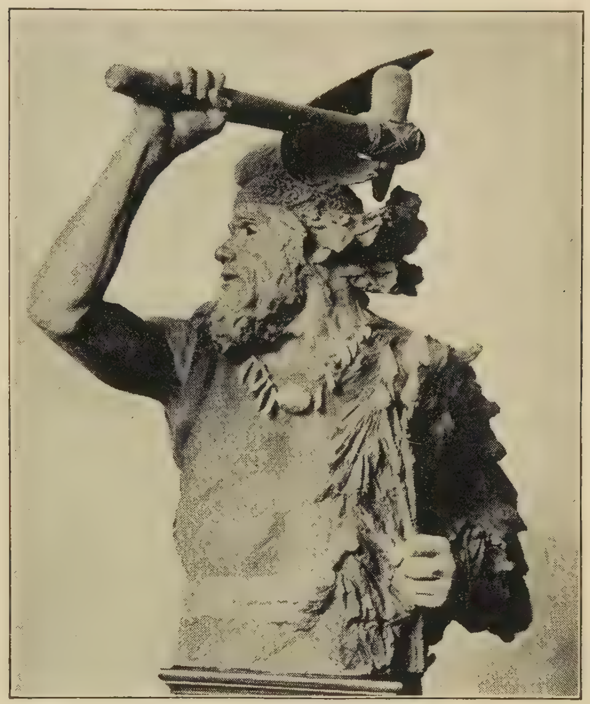
The religious ideas of this period can best be discussed in a general account of early religions. Plainly here was belief



EARLY AGRICULTURE.

From the mural by Fernand Cormon in the Museum d'Histoire Naturelle, Paris.

of a powerful and outstanding influence. Why else these giant tombs and monuments of colossal stones in an age when men were living in wattle huts? There are two other aspects of the period which deserve mention. No such stones could be raised, no such large groups could live together, without the beginnings of community organization, by tribe or clan or whatnot. There were also the beginnings of trade and commerce. Flint-mining was an active business carried on where the flint was best. Such a Neolithic mine has been found in Suffolk, England, known as Grime's Graves. Near by was a Neolithic workshop, with Neolithic tools in every stage of manufacture. In the mine were found deerhorn picks, and in their coat of chalk dust was still to be seen the imprint of



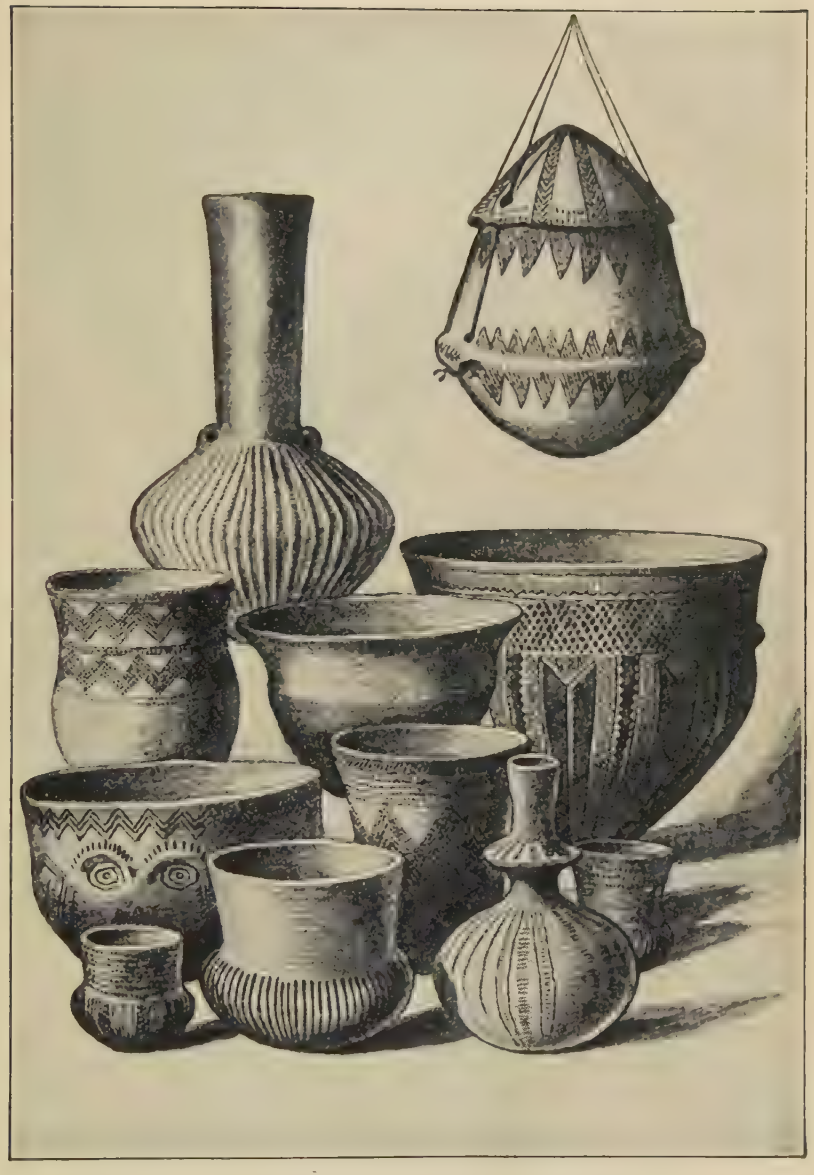
Courtesy American Museum of Natural History.

RESTORATION OF NEOLITHIC MAN, MODELLED BY THE BELGIAN ARTIST MASCRE.

Notice the polished stone axe, the knife, and the arrows, all typical of Neolithic culture.

the workmen's fingers just as they dropped the tools at the end of a Neolithic day's work. The amber found along the Baltic was traded in all over Europe by the end of the Stone Age. Strings of amber beads appear in graves far and wide.

The New Stone Age seems to have been above all a practical age, and it has left no art to compare with the Cro-Magnon art. Neither pictures nor carving appealed to these first herdsmen and farmers absorbed in the important business of conquering a comfortable living from the earth. Such love of beauty as they had they seem to have lavished upon the workmanship of their stone tools, which are often exquisite in shape and finish, though never decorated. They lived some 5,000 or 6,000 years, about the same length of time as the entire historic period. A slow, plodding age, it was, by comparison with later civilizations; but progress in material things was swift if compared with the 100,000 or more years of the Old Stone Age that preceded it. All they did is now taken for granted. They left no sign save these inarticulate stones, upstanding over Europe, ignored witnesses of a forgotten age. Yet modern man would be nothing without their hard-won gains. Civilization would have been impossible without these hidden centuries. With accuracy this New Stone Age can be regarded as the invisible foundation of the modern world.



POTTERY FOUND IN NEOLITHIC GRAVES.

CHAPTER IX

WHAT PRIMITIVE MAN THOUGHT AND FELT

HERE is most interesting but most difficult ground. It would be delightful to have a clear picture of these ancient hunters and first farmers, to understand how they lived at each stage of their slow evolution, and just when and by what stroke of luck or wit they discovered such marvels as fire and speech and religion. But the sources of knowledge are treacherous and vague, and to overdefine is to pretend to that which is not known.

There are several sources of knowledge:

1. Ancient remains (skulls, graves, stone implements, etc.).
2. Savage tribes as they exist to-day.
3. Children's games of to-day preserving ancient customs.
4. Religious ritual of historic times.
5. The minds of modern men.

The last source is a most treacherous influence and the hardest to correct. However much one tries, one is tempted to explain primitive man by thinking of what one would do under similar conditions. One guesses he discovered fire by striking flint, or dreamed of a dead man and thus invented ghosts and gods, because if we had been there, living as he lived, we should have done just that. The question is of historical imagination and the difficulty of understanding an alien and distant people. In sending one's imagination back yet farther to these first hairy ancestors, one meets a yet harder task. One must use what one knows of one's own mind to interpret these primitive minds, for it is the only mind one possesses. But one must continually remind oneself of the vast gap in experience that lies between.

To compare the mind of the savage to the mind of a child probably misleads more than it helps. For in his emotions the savage was anything but a child. It was in a world rich and warm with loves and hates, fears and joys, that the savage dwelt. Nor was his mind that of a child's, for he possessed a long array of acute outdoor instincts that enabled him, like Mowgli of the "Jungle Book," to sniff danger afar and tread the forest in safety. His whole body was a finer and suppler and stronger thing than any man's today. Man dwelt in it, and through it was immersed in the physical world in a fashion which a civilized man can touch only at times—perhaps best when one is swimming on a warm, sunny day and feels a little as if he were part of the sea. Finally, and most important, savage man was more completely a part of his group, his hunting-pack, his tribe, than modern man is part of his city or nation. He had to be, for day and night life and death depended upon skilled group action. So he was less of an individual than modern man, and his ideas and emotions were more group ideas and emotions.

I. LANGUAGE AND FIRE

One other invention preceded these two victories of early man. That was when man learned to walk on his hind legs, thereby freeing his fore paws so that they could become hands. But this was hardly an achievement of man, so far as can be guessed; it was rather the step that made man possible. The growth of language and the discovery of fire were the first great marvels wrought by man himself. Together they made it possible for him to wage a successful war against the mighty animals among whom he dwelt.

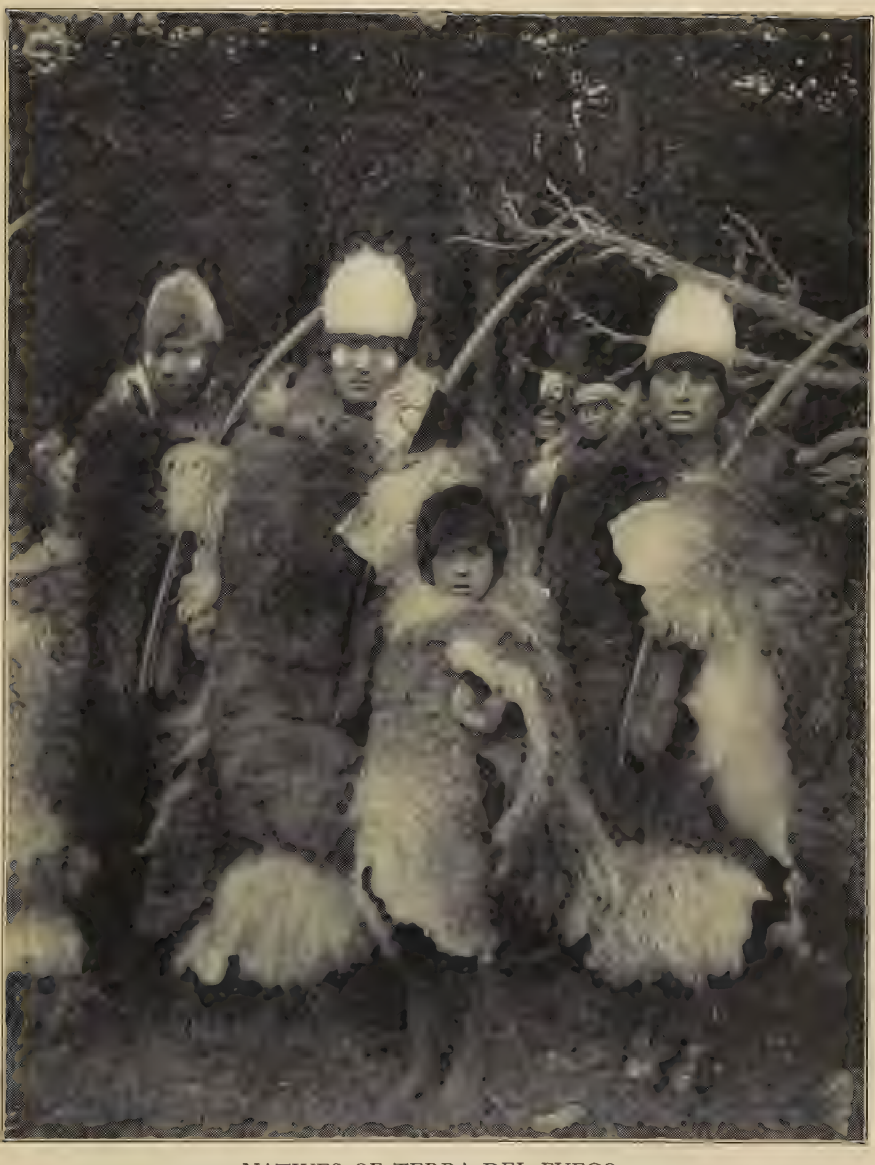
Man began to talk soon after he learned to walk on his hind legs, one can guess. But there is no scientific basis for reconstructing these beginnings of speech. Much theorizing was once done in an effort to demonstrate how primitive man must have hit upon his first words; but too much of the argument was based upon the habits of modern minds to make the results of much value. The more the languages of primitive man have been studied, the less support there is for these abstract theories. Thus a favorite thesis was that the earliest words imitated sounds, such as growl and hiss and screech. Language was conceived as beginning in a series of short grunts standing for the simplest ideas, fire, snake, buffalo, etc. But the languages of the most primitive savage show no suggestion whatever of such simple origin. Words based on sound resemblance are no more numerous than in civilized tongues. Nor are there many short words expressing simple ideas. Quite to the contrary, the savage's words have four or five syllables and express the most complicated group of ideas. Also there is a very large vocabulary considering the primitive minds that use them. It is often said that a European peasant uses less than 1,000 words in his lifetime; certainly one can express a vast range of ordinary ideas with that many words of a modern European language. The benighted savages of Tierra del Fuego have more than 30,000 words.

The savage thinks with the greatest difficulty of general ideas, and he has few words for them. Dog, water, moon, hand, knife, are ideas that any modern child can comprehend. The savage does not use such ideas freely in his mind or speech. If he thinks of a dog it is of a particular dog doing a particular thing, and he has one word that expresses every bit of this detailed picture. In the Huron-Iroquois language *eschoirhon* meant "I-have-been-to-the-water," *setsanha*, "Go-to-the-water," *ondequoha*, "There-is-water-in-the-bucket," *daustantewacharet*, "There-is-water-in-the pot." We have one word moon, and we put with it an adjective if we want to say full moon, the word full being equally a general word that we can combine with any other general noun. The Fuegians have two names for the full moon, each containing four syllables, and the two have no syllable in common. Building a verb is a fearful and wonderful proceeding for a savage, for it includes all sorts of definite details which we ignore in the general idea of a verb and add as we wish afterward. Thus, if a Ponka Indian wishes to say that "a man has killed a rabbit," he picks out a form of the verb and surrounds it with particles which include all these ideas: that the killer was a man, that he was one man, that he was an animate being, that he was standing, that he killed the rabbit intentionally, that he killed it with an arrow (or however he did it), that the rabbit was one rabbit, that it was an animate being, that it was sitting down (or however the rabbit was at the time). Nouns and pronouns are equally complicated and specific. There are often four numbers, singular and plural, and also forms to express two and three. The Klamath Indians have four forms for "this" and four for "that," indicating just how near or far the object is. For "this" he must choose between "near enough to be touched," "close," "upright, before the speaker," and "present, within sight." For "that" he has "visible but far away," "absent," "absent and gone away," and "beyond sight." There is a nominative and accusative for each of these forms. Speaking a savage language requires an excellent memory, and is a far more difficult achievement than speaking a civilized tongue.

This study of language takes one a long way into the savage's mind. He lives and thinks in a world of pictures, and when he talks he talks pictures. Ideas mean little to him and he has few words for general ideas. His language, on the other hand, is amazingly strong in the ability to paint clear, detailed pictures. One can paint a picture well enough in

English, but one must do it slowly, adding word after word and sentence after sentence, putting together a succession of separate ideas much as a painter would paint a picture with a long series of brush-strokes. The savage has single words, often five or six syllables long, which flash a whole picture in full detail. Portmanteau words these have been called, because so much is packed into them. Holophrase is the technical name for them. Listening to such words, the savage probably sees a more vivid series of pictures before him than moderns can convey. Man has gained immensely in logic, analysis, generalization, the ability to discover relationships between objects and to reason about them, and modern language is admirably fitted to modern thought. The savage's tongue is equally fitted to his thought. It is at once a superb medium for expressing his direct, vivid contact with the physical world and a hopelessly inadequate medium for progressing into a world of ideas as distinguished from things. The modern anthropologist lays great stress on this difference in language. To develop backward peoples, before all else give them a progressive language, he would contend. Whether the thoughts will follow the language is another question which science cannot answer. The gulf between savage man and civilized man is nowhere so clearly shown as in this matter of language.

There is one more clue as to the early speech of man which remains to be mentioned. That is the existence of sign-language far and wide among primitive peoples. Talking with

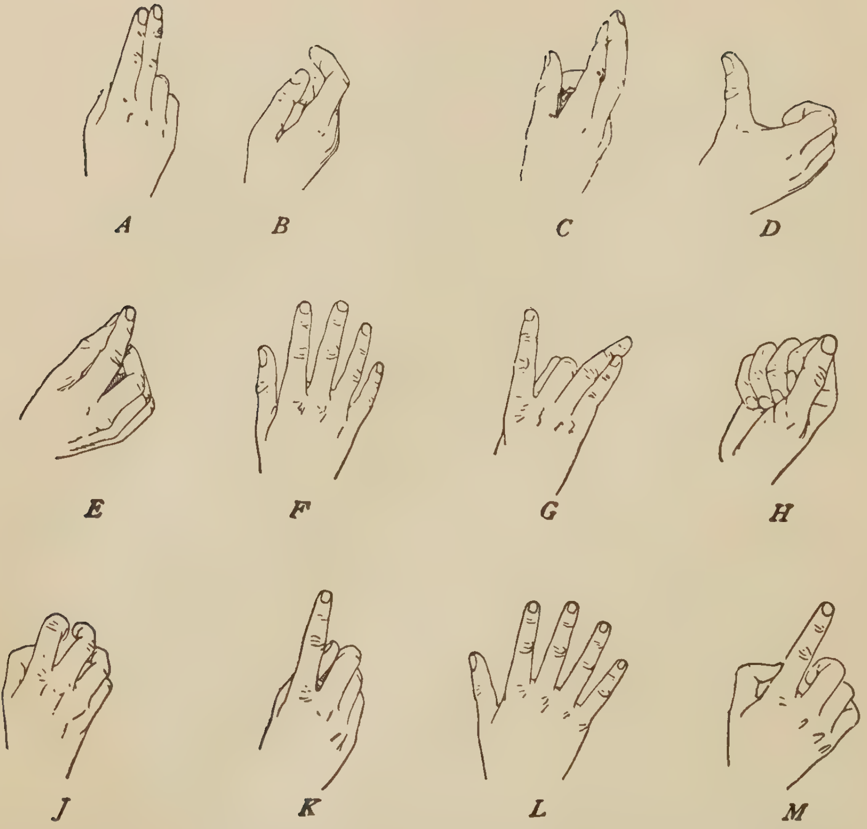


NATIVES OF TERRA DEL FUEGO.

hands, arms, shoulders, face is wide-spread. Tribes of North American Indians that cannot exchange a word will spend a whole day talking to each other by signs, recounting their adventures rapidly and fluently. Among certain Australian tribes a widow is forbidden to speak for twelve months after her husband's death. During that time she becomes at home in sign-talk. As a result, the women of the tribes often prefer this manner of speaking; Spencer and Gillen, the great English students of Australian customs, describe a gathering of women in which almost total silence reigned while an animated conversation went on. One widow was discovered who had not spoken, except with her hands, for twenty-five years. It can be taken as general truth that among primitive peoples the sign-language and the spoken word exist side by side, each aiding the other.

It is easy to see how signs might influence the development of speech, and interesting studies have been made along this line. If one hypothesis is more likely than another, one may perhaps look for a theoretical reconstruction of primitive speech in which signs play a large part. Such talk as the first men had may well have been more a matter of hands and face than tongues.

These are the only clues which exist as to primitive speech. It can be guessed that the hunters of the Old Stone Age in Europe developed some such holophrastic speech as survives among corresponding Stone Age savages of to-day—that Cro-Magnon man used portmanteau words as do the less-



WITH THESE AND OTHER SIGNS AUSTRALIAN NATIVES CAN CARRY ON LONG CONVERSATIONS.

A and *B* are the signs for "small kangaroo"; *C* is a "kangaroo rat"; *D*, opossum; *E*, dog; *F*, camel; *G*, emu; *H*, emu head; *J*, eagle-hawk; *K*, lizards; *L*, large lizard; *M*, very large lizard. These signs can have other meanings also, and movements of the hands and fingers are used to convey the shades of interpretation.

From Spencer and Gillen, "Across Australia." Courtesy of the Macmillan Company.

brilliant savages of to-day. But not a word of these languages has been preserved, and scientists face a doubt—which makes them view with suspicion all arguments drawn from the study of surviving savages—as to whether the savages of to-day are truly primitive peoples or are degenerate peoples. In the latter case their languages would be the relics of a more cultivated past, and would give no indication whatever of the speech of a truly primitive man experimenting for the first time with connected speech.

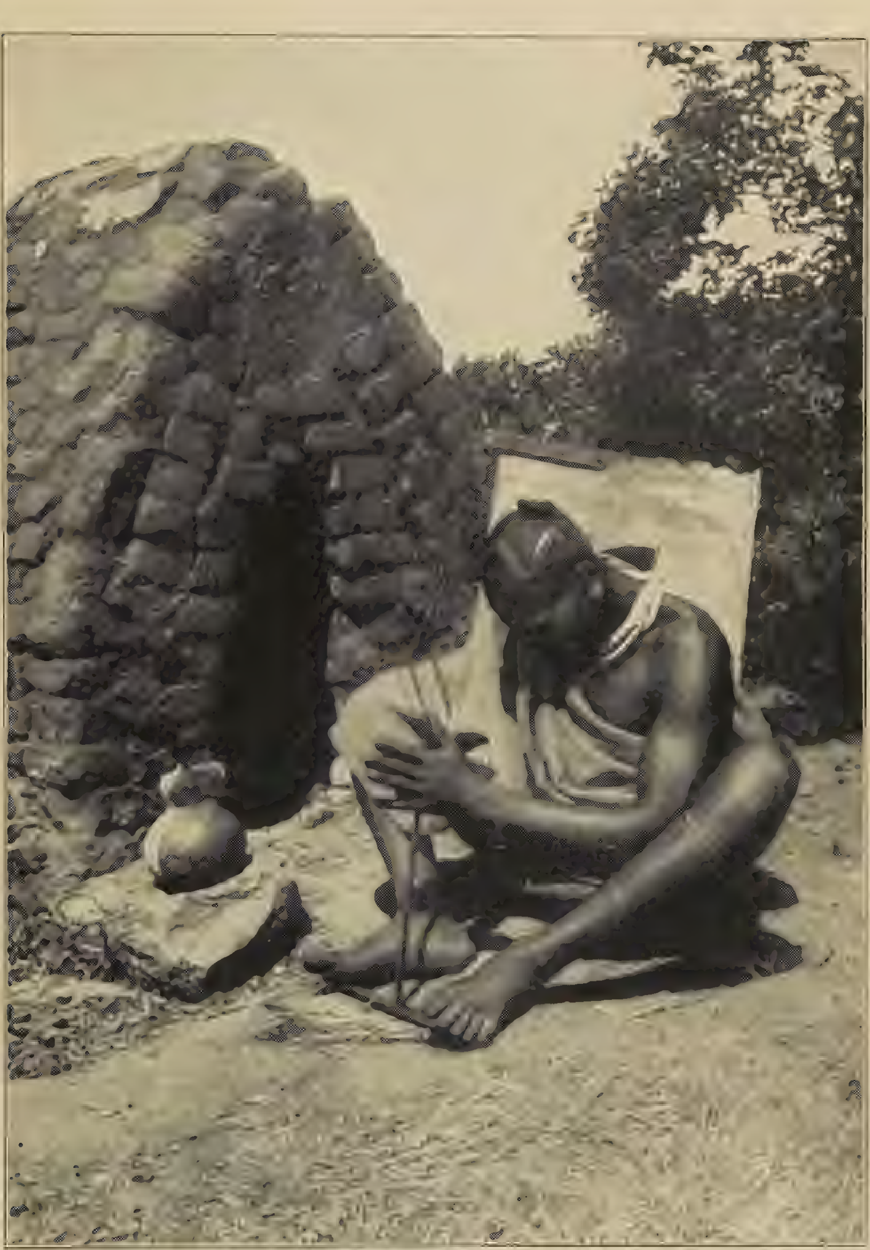
Nor is there any more certainty as to Neolithic times. There is no certainty that a word of Neolithic speech has been preserved. The herding and farming ancestors of man who inhabited Europe down to 2000 B. C., the hidden foundation of Western civilization, were overrun by invaders whose language, in one form or another, conquered all Europe. The one vestige of an older tongue that has lived into our time is the Basque tongue spoken by the Basque people of northern Spain and southwestern France. Philologists have countless theories about this strange speech, which resembles no other tongue in the world. Its origin remains a complete mystery. But its general character resembles that of the savage languages, and it can probably be considered as a survival of earlier speech. Conceivably it is a true descendant of the speech of the Neolithic ancestors of Europe, an island of Stone Age language, surviving in the age of aeroplanes. But this is only one hypothesis among many. Only the philologists, who study the evolution of words, can solve this interesting puzzle, and they are still far from a conclusion.

As for what words the first man uttered in that dim past of the race, hundreds of thousands of years ago, when a stone hatchet was an undreamed-of marvel of the distant future, science is even more completely in the dark. It is of speech developed to a highly complicated state by tens of thousands of years of slow evolution that savage language of to-day gives a glimpse. Peering back into the remoter mists, one can only feel sure of the immense remoteness of that hour when a hairy being, standing upright, partly with his hand, partly with his tongue, uttered that first and greatest of human inventions, a word.

The importance of fire to primitive man, surrounded by great carnivora, pursued by advancing glaciers, is clear. There is proof that the later Stone Age men made fire, and it can be taken as probable that their ancestors possessed this blessing for thousands of years before.

How man first hit upon fire has been much debated, but there is no way of reaching a conclusion. Very possibly it may have been discovered from different sources in different parts of the world. The lava of a volcano or a tree set on fire by lightning are possible sources. As soon as man began to make flint tools and happened to use an iron-bearing stone, he struck sparks. But what might seem to modern minds and customs the likely source of fire may not, in fact, have been the first source of fire to primitive man.

It has recently been suggested by a psychologist, C. G.



From a photograph by Ewing Galloway.

FIRE-MAKING BY FRICTION.

An African woman kindles a bunch of grass by spinning one stick against another. Fire can be obtained in half a minute by this method

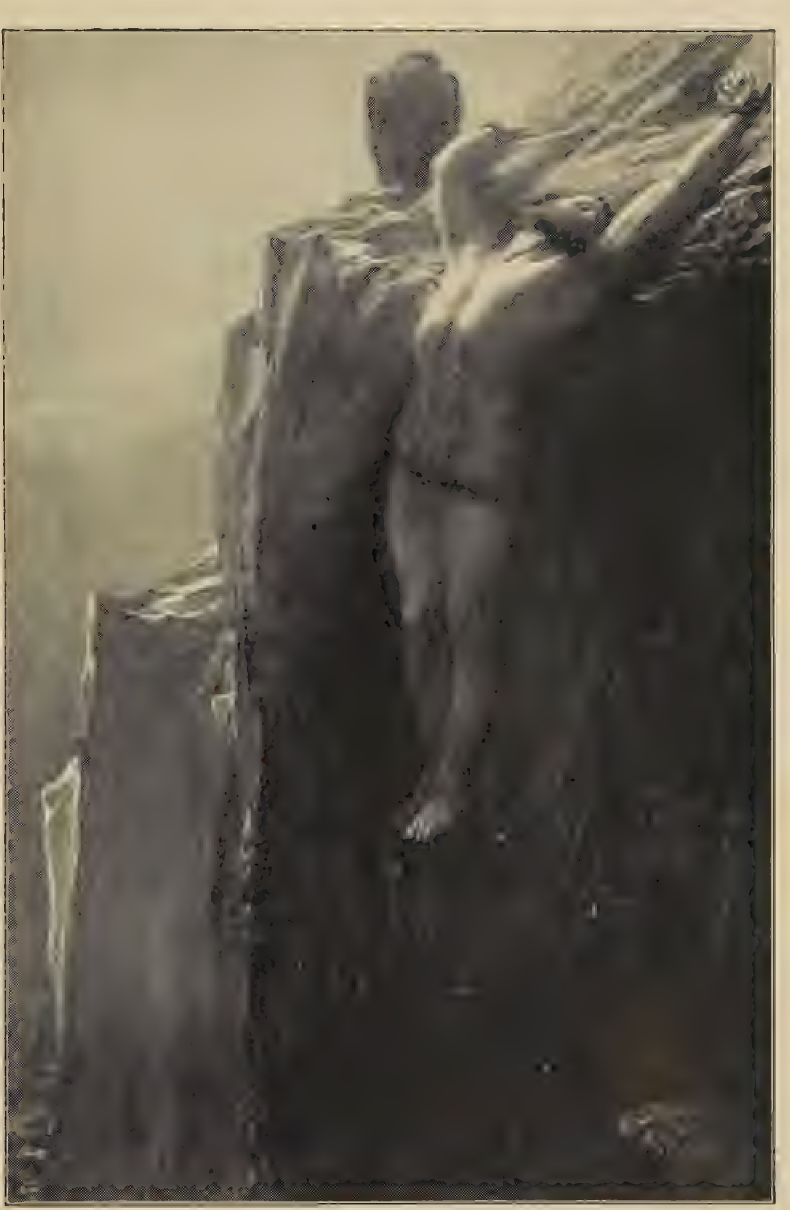
Jung, of Switzerland, that savage rites may have accidentally made the first fire by boring one stick into another, as in the fire-drill used by Boy Scouts to-day. He bases his suggestion on a study of ancient myths. Primitive man realized fully how precious fire was to him, and the fire-bringer is one of the earliest gods. In the Tonga Islands of the South Pacific, the god of fire is the god of earthquakes, as might be expected in a volcanic region. By a legend of North American Indians the great buffalo, galloping across the plains, struck sparks with his hoofs which set the prairie afire. For the Greeks, the fire-bringer was Prometheus, one of the greatest and most sacred of their gods.

The evidence yielded by such myths is unreliable and must be carefully checked. They, at any rate, give interesting proof of the vast importance of fire to early man. The blazing torch with which he first faced and drove back from his cave a terror-stricken animal might serve well as a symbol of the whole story of man's amazing triumph over the physical world.

2. SOCIAL ORGANIZATION

There is no direct knowledge of how primitive man united in groups, and for information scientists must again fall back upon the customs of savages still living. It might seem easy to catch a tribe of Australian natives who were living in the Stone Age, and by studying their ways infer how Neanderthal man or Cro-Magnon man organized his groups or tribes. But such evidence has to be used with large reserves. At the start comes the difficulty of finding out how a given tribe of savages does live. Their ideas are not our ideas; the whole substance of their daily existence is so far alien to ours that to pass beyond the most superficial facts requires long and sympathetic study by experts. Much of the evidence used by early anthropologists is now seen to be misleading, because it was gathered by casual travellers who made no attempt to comprehend the savage's point of view. It has been necessary to discard a number of supposed facts together with the theories built upon them. For a second point, as already noted, one can never be sure that a tribe under observation is not a degenerate remnant of a once higher civilization; in which case its social organization would offer no parallel whatever to that of a truly primitive people. It is only by comparing the customs of a large number of savage tribes that even a tentative hypothesis as to how early man organized his groups can be found.

The most primitive savages of modern times are already in the Stone Age. There is therefore no evidence whatever as to how man lived in that long night before the dawn of Paleolithic man. It can be guessed that, like his forebears, the animals, he hunted in packs and that, also like the animals, family ties helped in forming the pack. At the head of the pack one can conceive the strongest man acting as leader until, weakened by age, he was killed by a new leader. Fire had been discovered by Paleolithic times, so at some unknown point in these tens of thousands of years one may picture a



© *Reinthal & Newman, New York.* From the painting by Briton Riviere.

PROMETHEUS BOUND.

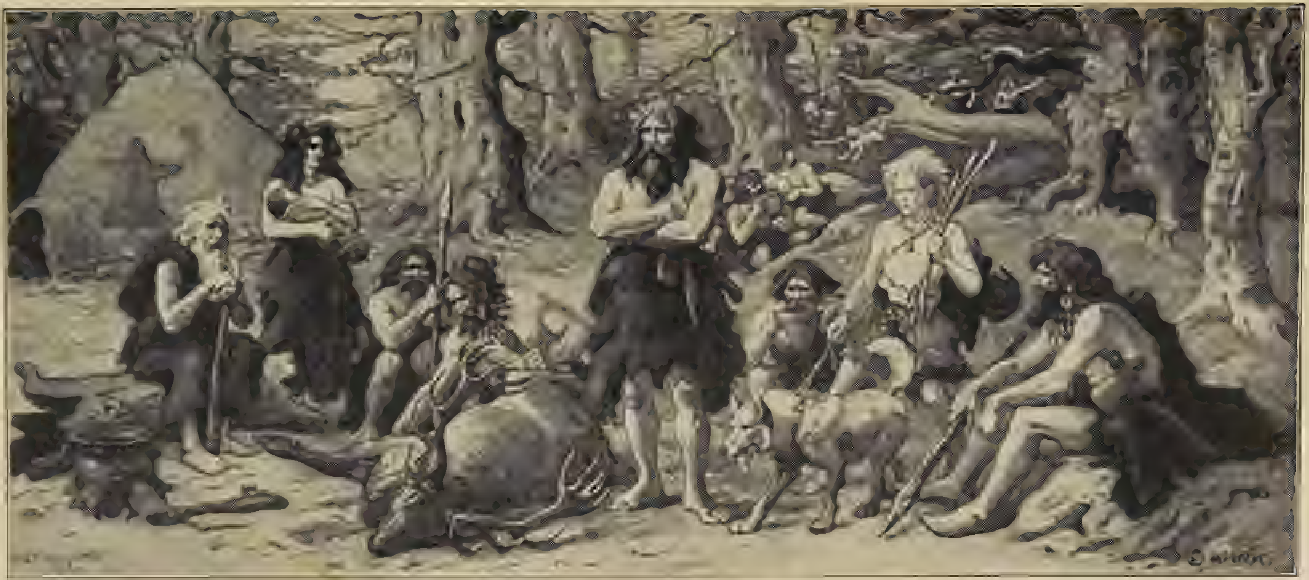
Because he stole fire from the Gods and gave it to man, Prometheus was chained upon a rocky cliff by Zeus and kept there in agony for nine hundred thousand years.

pack of men, women, and children, mostly related to one another, grouped about that terror of all animals, a blazing fire. This was before the discovery of stone weapons, and it can be supposed that man then used a wooden club. But all this is sheer surmise. It is tempting to fill in details from what is known of wolf-packs or monkey troops. But one must realize what one is doing. It is impossible to make even an intelligent guess as to how large these primitive packs were or how completely the family was the pack, let alone decide such details as to whether primitive man had one wife or many, and whether the family was more or less permanent.

When primitive man does actually emerge for us in the Old Stone Age—as tentatively reconstructed from a study of existing savages—he is already far removed from a mere hunting-pack. Indeed, the whole object of the hunting-pack, the getting of food, has been subordinated to a totally different affair. His group is not a food-group at all but a kinship-group, sometimes a very complicated and amazing family. Before examining this peculiar organization of savages, there should be noted the few rays of light which its existence casts backward into the earlier age of darkness. In view of it one can feel fairly confident that kinship, especially that of mother to child and of man and woman in some sort of primitive marriage, is one of the oldest facts in the human story. Men and women were hungry and in peril, and therefore they banded together to hunt and to kill; but equally they lived together and had children, and family ties shared with hunger the task of first organizing man in groups. That much of surmise as to early man rests upon solid probability.

Many savages of to-day live in family groups comparable to the simple family unit of civilized man. Not less frequently is found an artificial kinship system utterly unlike the small and natural organization of the modern family. Here (as in the case of language) progress has been toward simplification, not complexity. Nobody knows why these complicated tribal systems came to be, although anthropologists have waged war about the problem for a generation. Leaving these debatable causes to one side, let us analyze briefly, by way of illustration, one of the commoner types of such tribes. It must be understood that the variety of these kinships is endless and that many savages lack such a system altogether. In this particular tribe, there is a chief and a council of chiefs at the head. Thus far there is simply the hunting-pack grown to several score, or, in the case of North American Indians, several hundred members. But then comes the odd fact; the tribe is split from end to end into clans, usually two, sometimes more, and it is as a member of a clan that each savage first of all lives, and it is to his clan that he feels his first loyalty.

A striking feature of some clans is a totem, an animal or a plant, which is its sacred emblem and by which it is named. The Boy Scouts name their patrols after animals in much the same fashion. But the totem of the savage means far more



Courtesy American Museum of Natural History.

STAG-HUNTERS OF THE NEW STONE AGE.

These Neolithic men lived in huts instead of caves, had domesticated some animals, and while less artistic than the Cro-Magnons, were able to weave and make pottery.

From a painting by Charles R. Knight.

in his life. Often it is sacred to him; if it is an animal, he may not kill or eat it; and it plays a conspicuous part in his religion. In every case it unites the members by a bond, in a brotherhood, which moderns have difficulty in understanding. Secret societies and fraternities offer only a pale imitation of it. The Australian natives talk of being "all-one-flesh" in a clan because they are "all-one-flesh" with the totem.

A savage living under this system is born into a clan. He inherits at birth the clan either of his mother or his father. The former kind of inheritance is called mother-right, the latter father-right. It was for long argued that mother-right was earlier, and the word "matriarchate" was coined to describe a supposed condition in which the mothers of a tribe more or less ruled it. This conception has now been abandoned. The male seems generally to have been the more powerful in savage tribes; and as between mother-right and father-right, while there is some evidence that the former is more primitive, it is not conclusive. All that is known with certainty is that existing savage tribes follow either one rule or the other, and that when, issuing from savagery, they reach the stage of herding and farming, father-right and the patriarchal system usually prevail.

One more strange point remains to be noted. Generally speaking, the members of a clan are not permitted to marry within their clan. "Exogamy," meaning "marriage without," is the name given to this peculiar rule. Practically this rule may work out in a beneficent way, for it prevents close intermarriage between near relatives and compels what stock-breeders call cross-breeding. Perhaps this utility may have been at the bottom of the whole totem division. But there is no clear evidence, and the anthropologists are far from agreed.

The system of totem and exogamy is infinite in variety and complexity. Sometimes, under mother-right, the father simply visited the mother from time to time, and both lived on as before with their

Courtesy American Museum of Natural History.

A TOTEM-POLE OF THE HAIDA INDIANS OF CANADA.

separate clans. Sometimes, under father-right, the mother left her tribe and came to live with her husband, and there was therefore something like the modern family within the clan. One needs to remember only the broadest outlines. Perhaps the chief point to realize is that among savages the family as moderns know it (a father, a mother, and their children) was often swallowed up in a larger unit, the clan. A boy born of a Wolf father (in a tribe where father-right controlled) was first of all brother of all the other Wolf men (whether actually related to them or not). His father and mother had much to do with his bringing up, but the clan had more. His greatest loyalty was to the totem and the clan.

It is amazing to find that savage man has frequently organized himself in this highly artificial and complex manner. His whole life is similarly surrounded and marked out by custom. It is hard to find anything exactly like modern laws in savage tribes, for a law implies punishment for its breach, and the customs of a savage are seldom broken. What is forbidden is taboo, which is to say that the rules of the savage are sacred, and violation of them brings down not so much punishment as a terrible and unknown fate. That fate, to be sure, usually includes sudden death at the hands of the community, horror-stricken that a taboo should have been broken. But this is a detail beside the supernatural terror involved. The practical result is that the savage is more law-abiding than modern man. It seldom even occurs to him to break his customs, so completely are they a part of his nature.

That is the good side of this way of life. The bad side is that individual freedom is reduced to a minimum and that progress is difficult to achieve. The Dyaks of Borneo, for example, are a mild, good-natured race; yet their custom demands head-hunting, and head-hunting they still go. One need not jeer too loudly at this rigidity of savage custom, for

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A DYAK PIGMY CHIEF HOLDING A *PAPAIA*, AT WHICH HE HAS BEEN SHOOTING DARTS THROUGH HIS BLOW-GUN AT A DISTANCE OF 150 FEET.

modern man often shows much the same spirit. Moderns frequently cling to customs long after all purpose or use has been lost.

It is hard to say how much of all this can be safely applied to primitive man. There returns the difficult question of how far these savage customs are the work of truly primitive man and how far the work of degenerate man. Probably most anthropologists feel that there is here represented a genuine stage in human progress, obviously not of earliest man, but of man far along in the Old Stone Age. But the sceptic who doubts is hard to answer. One can feel at least convinced that the roots of modern law and custom and human relations are extremely ancient, and that man, while a hunter and a savage, was part of a complicated society, hedged round by untold rules and customs.

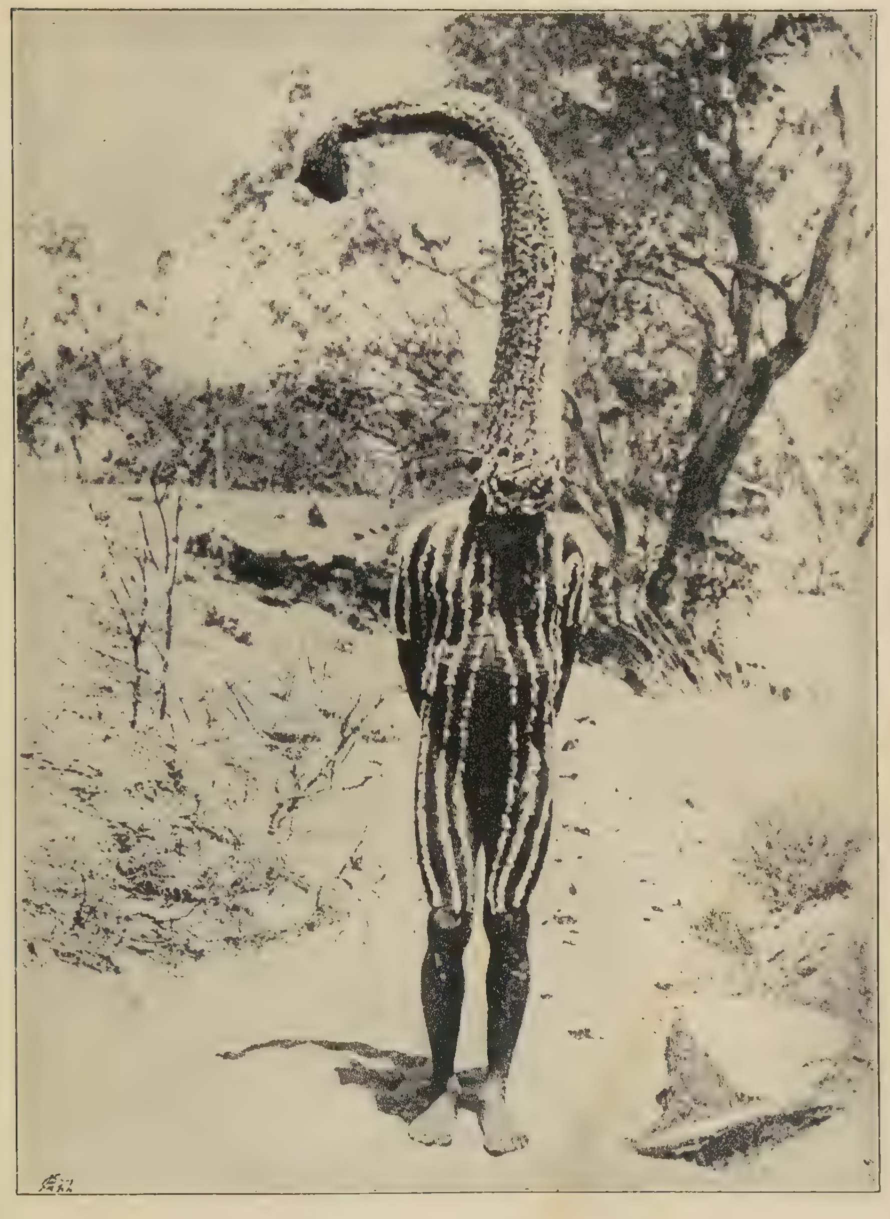
3. THE SUPERNATURAL

In central Australia there is a long, dry season in place of winter and a short summer season of torrents. Nothing grows in the period of drought. When the rains fall, the dry steppes blossom suddenly with plants, and birds and frogs and lizards appear as if from nowhere. The Australian native of this region goes through strange performances each year just before the rain is due. He draws the figure of the emu on the ground in his own blood. Then he puts on feathers of this great ostrichlike bird and gazes about vacantly, imitating its stupid look. Also he imitates the birth of a caterpillar, the witchetty grub, from its chrysalis. He builds a large chrysalis of branches and drags himself through it. The emu clan perform the emu rites, the witchetty-grub clan the grub rites. The clan that has the kangaroo for a totem go through even more elaborate rites. The kangaroo men go to a lonely rock face, where first they paint stripes of red ochre and white gypsum (like the red fur and white bones of the kangaroo). Then a chosen few mount to a ledge some twenty feet from the ground, open veins in their arms, and let their blood drip down upon the rock. Meanwhile, below, the other

CEREMONY OF THE KANGAROO TOTEM.

The ledge of rock with stripes represents the kangaroo. Above the stripes blood has been poured during the ceremony.

From Spencer and Gillen, "Across Australia." Courtesy of the Macmillan Company.



CEREMONY OF THE EMU TOTEM.

The head-dress represents the neck and head of an emu.

From Spencer and Gillen, "Across Australia." Courtesy of the Macmillan Company.

men sing chants about the kangaroos to come. After this ceremony is finished, they hunt till they kill a kangaroo, which they divide and eat. (It is only at this special ceremony that the kangaroo men can eat their totem animal freely.) Afterward, they smear their bodies with red and white stripes as they smeared the rock.

This seems savage nonsense. Yet the modern world is not many generations removed from similar rites. The May-pole is to-day the centre of children's play. In England, as recently as the days of Queen Elizabeth, it was a festival in which whole villages took part. There were scores of oxen, decked with flowers, drawing a living tree, and hundreds of men, women, and children, dancing and feasting, among them the Queen of the May. In Bavaria, May-day is still celebrated in this fashion. In ancient Greece there was an April festival that centred around a garlanded bull and a procession that ended in the killing of the bull as a sacrifice to Dionysus, the god of youth and springtime. These spring ceremonies belong to a period later than savagery, when man had begun to till the soil. His interest is not in kangaroos but in bulls and the spring planting. But the resemblance is plain.

There is more solemnity in the Greek festival and more fun in the English festival—which is doubtless a survival of earlier and more solemn rites. What the central Australian is thinking of when he turns emu or grub or sings about the kangaroo, it is most difficult to determine. No two festivals celebrating spring are the same, nor is it always spring that is celebrated. Autumn festivals, like the American Thanksgiving Day, are common. The Eskimos are chiefly concerned about their arctic winter, and every autumn they divide into two groups, called Ptarmigans and Ducks, and have a tug-of-war with a sealskin rope. If the Ducks win, there is hope of fair weather, if the Ptarmigans, bad. The tug-of-war, like the May-pole, seems generally to be a survival from early festivals related to the seasons.

In all these ceremonies dancing, or at any rate acting as in a children's game, plays a large part. As a matter of fact, dancing is a common form of expression among savages. War-dances and rain-dances are familiar illustrations among the North American Indians. The savage dances not for amusement but always with a solemn purpose. He is face to face with a danger, he hopes and longs for something, and he performs these rites, seasonal or otherwise.

Perhaps the most elaborate rites of all take place when the boy is old enough to play his part among the men of his clan and he undergoes the ceremony of initiation. There are initiation ceremonies to-day, for college fraternities and secret societies; they are more or less solemn, and they very often involve some test that is thoroughly disagreeable to the one initiated. In this last respect they resemble the savage initiation. The boy of a savage clan may have a tooth knocked out and be obliged to fast for weeks alone in the jungle and be subjected to all kinds of unearthly, nerve-racking tests. The savage initiation is highly solemn and important. The boy learns the sacred customs of his clan under conditions calculated to sear them in his memory.

Oddly enough, a frequent accompaniment of the savage boy's initiation has become a modern boy's toy. That is the bull-roarer. It is a short, flat stick, an inch or two wide and eight or ten inches long. Sometimes the edges are notched, sometimes plain. A string is tied through a hole in one end. When whirled around the head at the end of the string, it

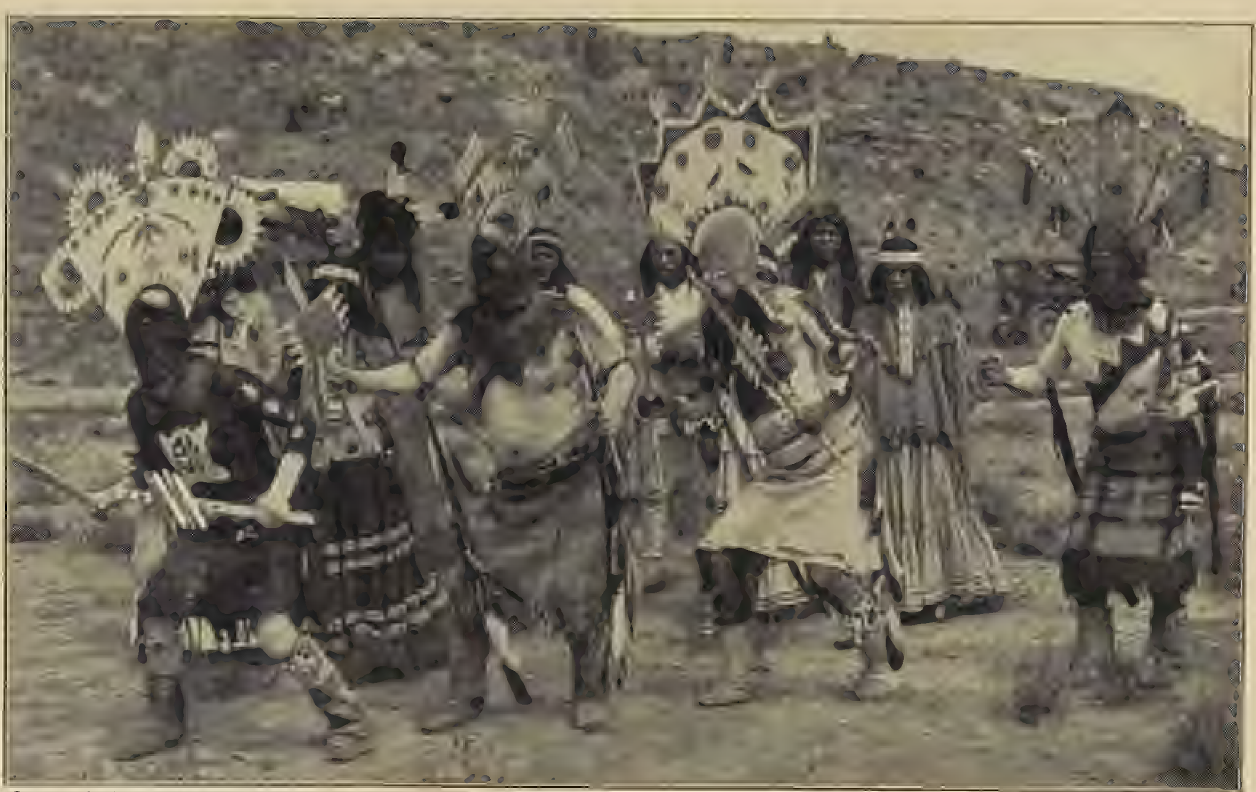
Courtesy Atchison, Topeka & Santa Fe Ry.

THE SNAKE-DANCE OF THE AMERICAN INDIAN IS AN INVOCATION OF THE RAIN SPIRIT.

gives out a strange, unearthly noise a little like the wind or distant thunder, or the deep note of an organ. It is a common toy of boys in England, sometimes called a hummer or a buzzer. The medicine-men of the Apache Indians were still using it a few years ago as part of their rain-spell. It was used in ancient Greece in the spring rites to Dionysus. It has been traced around the world and discovered upon every continent. In southeastern Australia it furnishes the voice of the god at the initiation ceremonies. It is against this background

KNOCKING OUT A TOOTH IS PART OF THE INITIATION CEREMONY FOR BOYS IN THE KAITISH TRIBE.

From Spencer and Gillen, "Across Australia." Courtesy of the Macmillan Company.



Courtesy Atchison, Topeka & Santa Fe Ry.

THE APACHE INDIANS STILL DO THEIR ANCIENT CEREMONIAL DANCES, SUCH AS THIS DEVIL-DANCE

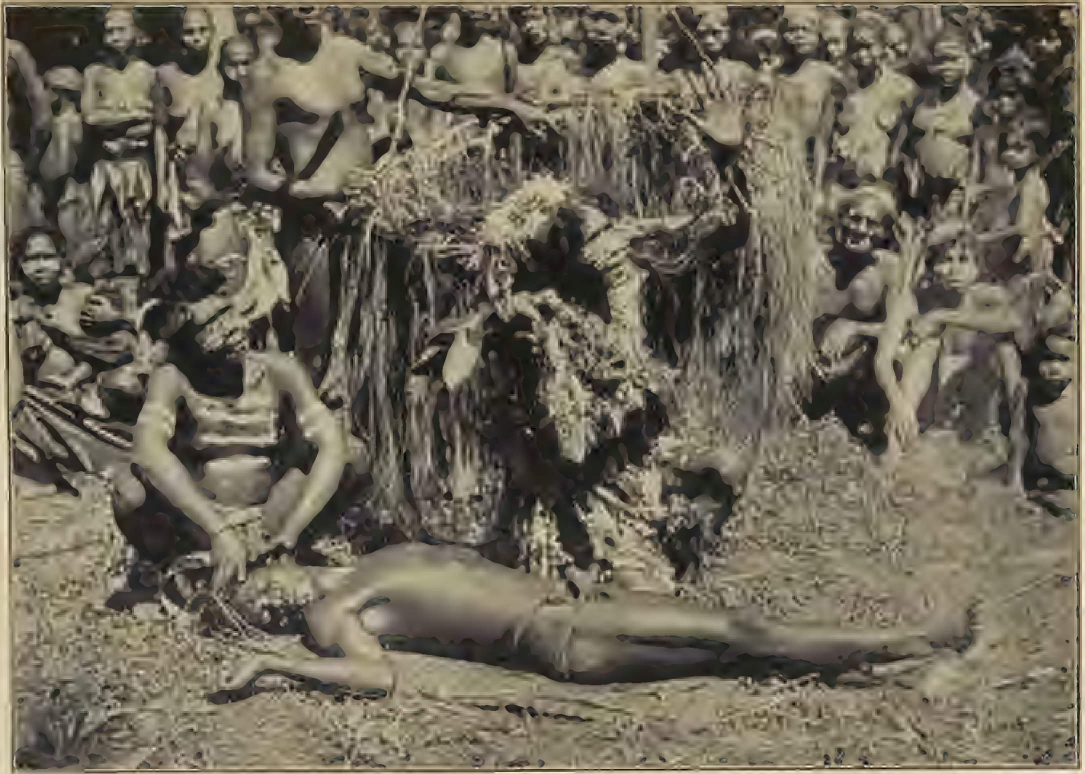
of mysterious, throbbing sound that the savage boy takes up his solemn duties to his clan.

It is difficult to say exactly what the savage is aiming at in these various ceremonies. There are two simple explanations which can be given and which are summed up in the words magic and religion. These words have been purposely avoided thus far, and at the head of this section is the word "supernatural." Even that term is misleading, for moderns draw a sharp line between natural happenings that they can explain, and supernatural that they cannot, and place few things on the supernatural side; whereas the savage probably drew no such sharp line, and felt a large supernatural factor in most things that happened. But the word is at least less misleading than magic or religion. For the former means a definite thing, the use of supernatural forces generally evil; and the latter signifies belief in a god or gods, and implies acts of worship. To use either of these words injects wholly modern conceptions into primitive man and begs the question under consideration.

This is in effect a warning against two theories which have been widely debated for a generation. The one was put forward by a great English anthropologist, James G. Frazer, author of "The Golden Bough," a famous history of primitive custom. It assumes that practically all of these early rites are magic, and that magic generally preceded religion. "Sympathetic magic" was the precise term used by Frazer. The savage belief that one can kill his enemy by destroying an image of him illustrates the idea stressed—there was thought to be a "sympathy" between the image and the real person which worked the magic. The second theory was the hypothesis of E. B. Tylor, also an Englishman, the pioneer of all modern anthropology. He suggested that the early ideas of man about supernatural things started from dreams and the fear of ghosts, and caused him to think of everything about him, sky, trees, animals, what-not, as inhabited by spirits—to be haunted, so to speak. "Animism" is the name given to this theory, meaning that it is a theory of spirits.

Both of these hypotheses were the suggestions of able minds and both have served to direct and clarify thought about a difficult question. Both undoubtedly point to and explain certain forms of primitive custom. But the recent tendency of anthropologists is to regard both theories as misleading when broadly applied to the whole field, for the reason that they involve reading into the savage mind modern notions. The current tendency is to consider that the time is not ripe for attempting a definite theory of the origins of man's attitude toward the supernatural. Much more sympathetic study of savage man is necessary before scientists can be sure what is really in his mind when he does the strange things described.

But leaving aside definite notions of magic and religion, one can accept certain broad considerations as to the general type of savage thought and emotion. First, comes the fact that primitive man is above all a part of his group. The



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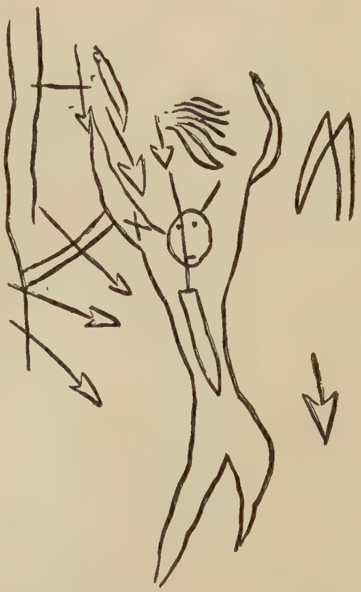
A DYAK WITCH DOCTOR, IN FULL CEREMONIAL REGALIA, MAKING MAGIC TO CURE A SICK TRIBESMAN.

doings described above are not individual doings; they are rites done on behalf of the community and by the community. The magic theory and the animistic theory both look to the individual mind for origins of these customs, whereas it is more likely that they are the product of some kind of joint action. At any rate, one must bear constantly in mind this pooling of ideas and emotions and not stress individual imagination at the expense of community custom.

Second stands the undoubted fact that many of these practices come at danger-points in the savage's life, when he is face to face with grave perils of starvation or death, and that they are solemn rites which in some fashion serve to help the whole tribe over these spots. The savage's unknown is a far greater part of the universe than is modern man's. It is difficult to put oneself in his place, so much of nature is now clear and so largely have the risks of starvation and death at the hands of wild animals been eliminated. It is not only a group of undeveloped human beings that must be pictured, but such a group hourly, daily, year after year, fighting for their lives against a world that stalked them by night and loomed threateningly by day. This is to say that such customs as those of the central Australians did for the savage much that religion and worship do for man to-day. They were solemn acts of ritual that helped him to face the unknown. In this sense, whether they prove to fall within modern conceptions of religion or not, they may fairly be said to have served as his religion.

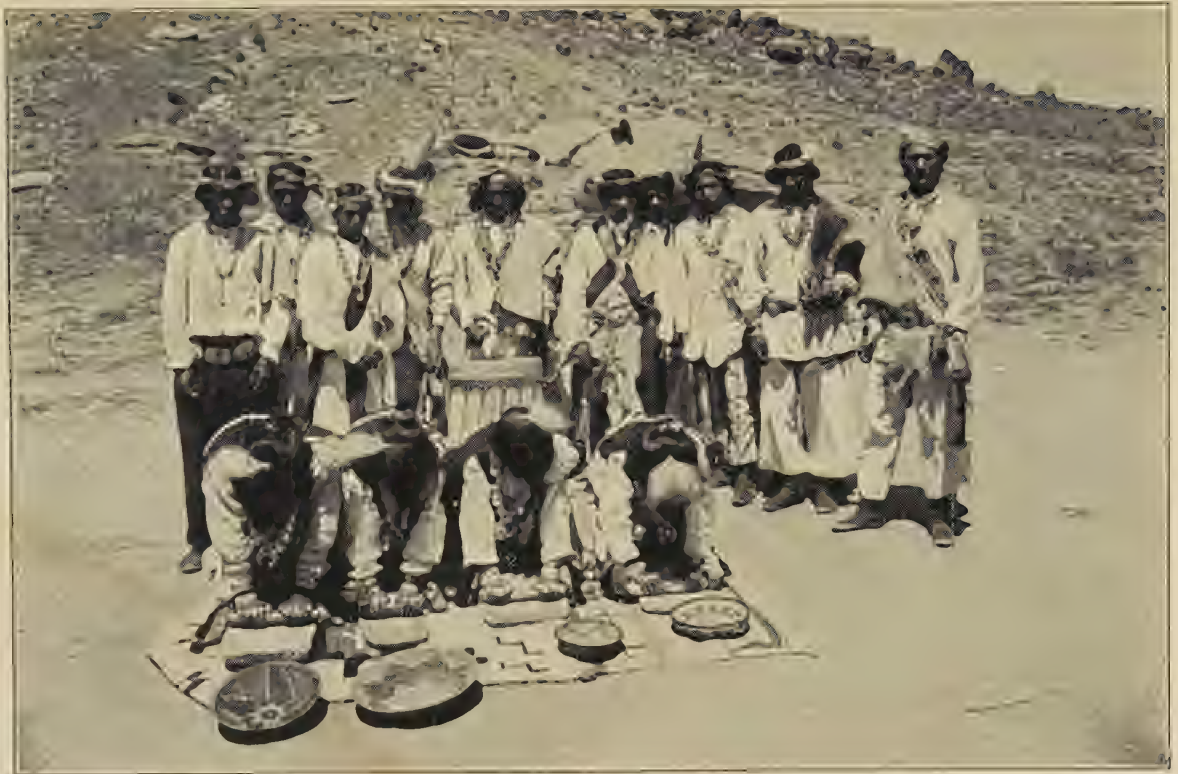
It must be accepted also that the savage early used other ceremonies which suggest much more closely modern notions of magic—the enemy-killing spells which Frazer described, for example. At any rate, they served much the same selfish, individual purpose for which later magic was generally used. No clear line of division is possible, however. One can only feel fairly confident that in the solemn community rites, designed for the good of the entire tribe, there is something that appears to be a forerunner of religion not magic.



THIS FIGURE, ENGRAVED ON A ROCK IN ONE OF THE CRO-MAGNON CAVES, IS THOUGHT TO REPRESENT A HUMAN SACRIFICE.

After Breuil.

Third, there is a very general idea involved in these primitive customs summed up in the Polynesian word "mana" and the Huron Indian's "orenda." Mana is the power of sacred things—the wonder-working quality of a chief or a bull-roarer or anything that a tribe considers sacred. It can pass into oneself or into one's spear-thrower, and this getting of mana is one of the great objects of such customs. It dwells above all else in the totem of the tribe. But the savage also feels it in the sun, the flash of lightning, the roll of thunder, in everything mighty and mysterious. Is this



Courtesy Atchison, Topeka & Santa Fe Ry.

THE CEREMONIAL CORN-DANCE OF THE INDIAN SEEKS TO PROVIDE FOR A GOOD CROP.

mana a soul or spirit, or is it a force, or is it simply a mysterious something? One can see how easy it is for a modern observer to read into such a belief the modern idea of a god. But probably, for the most primitive savages, mana is nothing so definite as a god or a spirit. Perhaps one can conceive the savage's approach to mana by thinking of one's own first vague sense of awe before the Falls of Niagara or a great storm at sea; yet the instant one reflects one is thousands of years away from the savage, and coloring emotions and ideas with thoughts he never had. When a primitive man succeeded in possessing mana himself, he probably felt a sense of power somewhat akin to that created in modern man by a stimulant.

Until more progress is made by anthropologists, these early customs must be left in this vague and unsatisfactory state. There is no question that on leaving the most primitive peoples there soon appear clear ideas of spirits and gods. Most savages surviving to-day—the tribe of southeastern Australia, cited above, and the North American Indians, for example—have reached this stage. The mythology of ancient Greece illustrates it at its culmination after man had ceased to be a savage and a hunter and had begun to herd his flocks and till the soil. How they developed from these hazy beginnings is still one of the endless puzzles of anthropology. The Tylor theory of animism assumes an early tendency to personify sun, tree, and waterfall resulting from dreams of the dead and a belief in ghosts. The Old Man of the Tribe, feared in his life and feared even more when dead, developed into the first god in this view. The Frazer theory of magic would derive the idea of a god from the practice of magic spells and sacrifices. In a study of Greek festivals Jane E. Harrison traced the conception of a god of youth and springtime first to the bull that was sacrificed and later to the leadership of a chosen youth in the seasonal rites. One need not attempt to remember these different speculations,

From Lumholtz, "Through Central Borneo."

STAFFS, CALLED PANTARS, ERECTED IN MEMORY OF THE DEAD BY THE NATIVES OF CENTRAL BORNEO.

for they are still unproven. The most important facts to realize are that man early felt the need of such aid as he later found in religion, and elaborately and solemnly besought such forces as he knew.

From Lumholtz, "Through Central Borneo."

PROTECTING AGAINST EVIL SPIRITS. KASUNGAN.

The carved representation of a tiger cat, holding a human head, serves as a warning to evil spirits.

There needs to be noted, finally, the large part which primitive art played in these ceremonies. Dancing and painting are both prominent. Perhaps the bull-roarer can be called the first music. Miss Harrison endeavored to trace the development of Greek tragedy, one of the greatest of all artistic achievements, back to those same spring ceremonies of Dionysus. One recalls the rock-paintings of Cro-Magnon man, a world away from the rock-paintings of the central Australians in space and in artistic ability. That they played a part in somewhat similar rites is altogether probable. There are just as many theories of the origin of art as there are of the origin of religion. The seeking of pleasure and joy in beautiful things has very largely driven the religious motive into the background in modern times. But whether religion and art originated together or separately, one can be sure of their close connection through long ages. They were bound together in Egypt, in Greece, in the Middle Ages. It is interesting to note their close kinship here in the farthest mists of time.

HE STREAM OF HISTORY

2. OUR FRAGMENT OF THE SUN

3. THE EVER CHANGING EARTH

4. THE MYSTERY OF LIFE

5. FROM AMOEBA TO MAN

ALASKA
CANADA
UNITED STATES
MEXICO
CENTRAL AM
VENEZUELA
COLUMBIA
EQU
PERU
BRAZIL
BOLIVIA
CHILE
ARGENTINA
HAWAII I.
NEW ZEALAND
PACIFIC OCEAN
ATLANTIC OCEAN
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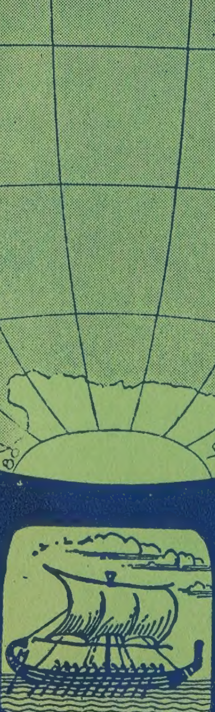
IVILIZATION

12 THE COMING



6. THE COMING OF MAN

7 HUNTERS OF THE OLD STONE AGE

8. HERDSMAN OF THE NEW STONE AGE

9. WHAT PRIMITIVE MAN THOUGHT

10. DAWN OF C
IZATION

RUSSIA
SIBERIA
FRANCE
SPAIN
MONGOLIA
MANCHURIA
KOREA
JAPAN
TURKEY
TURKESTAN
SINKIANG
TIBET
CHINA
LYBIA
EGYPT
IRAQ
PERSIA
AFG.
ARABIA
HEJAZ
INDIA
Sahara
FRENCH WEST AFRICA
SUDAN
ADEN
SIAM
PHILIPPINE ISLANDS
NIGERIA
FRENCH EQUAT. AFRICA
ETHIOPIA
SOMALI
CONGO
ANGOLA
UNION OF S. AFRICA
DUTCH EAST INDIES
AUSTRALIA
INDIAN OCEAN
20
0
20
40
60
80
100
120
140
20
40
80